Transactions of
American Society for Steel Treating

Vol. XII October, 1927 No. 4

FEATURES

TRANSACTIONS
American Society for Steel Treating

VOL. XII — OCTOBER, 1927 — NO. 4

NEW OFFICERS NOMINATED

IN accordance with the constitution of the Society the National Nominating Committee as duly elected by the chapters of the Society met on Monday morning, September 19, 1927, at 10:00 A. M., and nominated the following men as officers of the Society:

For President . . . . FREDERICK G. HUGHES
For Vice-President . . . . ZAY JEFFRIES
For Treasurer . . . . J. M. WATSON
For Director . . . . T. E. BARKER
For Director . . . . W. H. PHILLIPS

In accordance with the revisions to the Constitution of the Society as approved at the annual meeting of the Society Wednesday, September 21, 1927, if no other candidates for officers or directors be nominated as provided in Article XI, Section 4, subdivision C, then the National Secretary shall notify the tellers, who shall certify the election of the candidates nominated. This method of election renders unnecessary the sending out of letter ballots where there are no nominations other than those presented by the regular nominating committee.

BIOGRAPHIES OF NOMINEES

Frederick George Hughes
Nominated President of the Society

FREDERICK GEORGE HUGHES, Vice-President of the New Departure Manufacturing Company, Bristol, Conn., was born May 1, 1878, at West Cornwall, Conn. He was educated in the public schools of Bridgeport, Conn., later entering Sheffield Scientific School at Yale University, graduating therefrom in 1900 with degree of Ph. B.

FREDERICK G. HUGHES
Nominee for President of the Society for the Year 1928

ZAY JEFFRIES
Nominee for Vice-President of the Society for the Year 1928

JOHN M. WATSON
Nominee for Treasurer of the Society for Two Years (1928-29)

THEODORE E. BARKER
Nominee for Director of the Society for Two Years (1928-29)

WILLIAM H. PHILLIPS
Nominee for Director of the Society for Two Years (1928-29)

His first occupation after completing his collegiate course was in 1900, as engineer with Bethlehem Steel Company at South Bethlehem, Pa., later becoming assistant engineer of experimental ordnance, remaining there until 1905, after which he became chief engineer of the Driggs Seabury Ordnance Corporation of Sharon, Pa., remaining there until 1911, when he went to Bristol, Conn., and entered the employ of the New Departure Manufacturing Company, as chief engineer, and in 1914 was made production manager; assistant general manager in 1916, and director and vice-president in 1919.

He is also a director of the Bristol Realty Company; president of the Bristol Chamber of Commerce; director of Connecticut Chamber of Commerce; member of Endee Club of Bristol; Chippanee Country Club of Bristol; Society of Automotive Engineers; American Society of Mechanical Engineers; and of the American Society for Steel Treating. He was for several years chairman of the Ball and Roller Bearings Standard Division of the Society of Automotive Engineers.

In 1924 Mr. Hughes was elected as director of the American Society for Steel Treating, serving for two years (1925-26), and in 1926 was elected as vice-president for the year 1927.

During the World's war, Mr. Hughes was an advisory engineer to the Quartermaster department. He was also a member of the War Service committee on bearings.

Zay Jeffries

Nominated Vice President of the Society

ZAY JEFFRIES, consulting metallurgist of the Aluminum Company of America; consultant, Incandescent Lamp Department of the General Electric Company at Nela Park, Cleveland, Ohio, and consultant, National Tube Company of Pittsburgh, Pa., was born April 22, 1888, at Willow Lake, South Dakota.

Zay Jeffries was educated in the public and high schools of Pierre, S. D., graduating from the latter in 1906, later taking a course at the South Dakota School of Mines, Rapid City, South Dakota, graduating therefrom in 1910 with degree B. S. (Mining Engineering); in 1914 he received the additional degree of Met. E. (Metallurgical Engineer); in 1918 he received the degree, Doctor of Science (S. D.) from Harvard University.

In 1911 he accepted a position as instructor in Metallurgy at Case School of Applied Science, Cleveland, Ohio, and in 1916 he was appointed Assistant Professor of Metallurgy at the same School. While there he carried on consulting and experimental work in metallurgy for the Electric Railway Improvement Company, Cleveland Steel Tool Company, W. S. Tyler Company, the Lincoln Electric Company, National Lamp Works of General Electric Company (Cleveland Wire Division), and the Aluminum Castings Company, all of Cleveland, Ohio.

In 1917 Mr. Jeffries resigned from Case School of Applied Science, and since then he has devoted most of his time to research work for the Aluminum Company of America and the Incandescent Lamp Department of General Electric Company.

Dr. Jeffries has rendered invaluable service to the society, having been treasurer for the past four years.

John Mitchell Watson

Nominated for Treasurer for Two Years

JOHN MITCHELL WATSON was born at Providence, R. I., in the year 1883. He attended the University of Michigan, receiving his B. S. degree in 1909.

He has been associated with the Texas Portland Cement Company of Dallas and the Packard Motor Car Corporation of Detroit as chemist. In 1910, he became engineer of tests with the Sheldon Axle Company, Wilkes-Barre, Pa., and later accepted his present position as Metallurgical Engineer with the Hupp Motor Car Corporation, at Detroit.

Mr. Watson is the author of a paper on the "Practical Aspects of Metallurgical Work," presented as a part of the symposium on metallurgical education given at the Detroit Convention of the American Society for Steel Treating in 1922. He also presented a paper entitled, "Heat Treatment of Automotive Parts," before the Convention of the above Society held in Boston, in 1924. Mr. Watson is a member of the Society for Automotive Engineers, the American Society for Steel Treating, the American Society for Testing Materials and the British Iron and Steel Institute.

Theodore E. Barker

Nominated for Director for Two Years

THEODORE E. BARKER was born at Janesville, Wisconsin, April

16, 1872. His early education was received from the village school and high school. This was supplemented by evening courses and home study in mechanical and electrical engineering.

A bent for mechanics and scientific subjects was exhibited at an early age. While in his early teens he entered a machine shop and foundry as an apprentice. At the age of 23, he became foreman in a machine shop. When engaged as production engineer for a machinery manufacturing concern, in 1910, he first became actively interested in the heat treatment of steel. In 1917, Mr. Barker became the first Chairman of the first organized movement to promote the science of steel treating in Chicago, a section of the Steel Treating Research Society.

After operating for a year under the former name, the American Steel Treaters Society was formed, he was president of this society for two years, during which time twenty of the thirty-six chapters now constituting the American Society for Steel Treating were organized.

After the amalgamation of the Steel Treating Research Society of Detroit with the American Steel Treaters Society under its present name, in 1920, he served one year as first vice-president, resigning because of a change in business connections.

At the annual convention in Detroit in 1922 Mr. Barker was honored by the American Society for Steel Treating with a founder membership. He has also been associated with many other technical organizations as: Western Society of Engineers, Western Efficiency Society, National Safety Council, Illinois Manufacturers Association, Industrial Relations Association of America, National Pressed Metal Society and Die, Tool, Special Machinery and Manufacturers Association.

William H. Phillips, Jr.

Nominated for Director for Two Years

William Hopestill Phillips, Jr., was born in Bath, New York, on July 8th, 1887, receiving his early education at Haverling High School of that village, later attending Cornell University, graduating in 1912 with Degree of M. E.

Coming to Pittsburgh he became associated with the Jones and Laughlin Steel Company in the Operating Department. He took two years special work at Carnegie Institute of Technology in Metallurgy. He later became associated with the R. D. Nuttall

Company, as manager of works and engineering, and is now consulting metallurgist for this company. He has been associated with the Molybdenum Corporation of America since 1925.

Mr. Phillips has been actively interested in the American Society for Steel Treating since its inception, having been chairman of the first chapter organized in Pittsburgh and again chairman in 1926. He has presented many technical papers and written several articles on the subjects of metallurgy and gearing. During the last few years he has contributed liberally of his time to committee work, being a member of the Tool Steel Committee, the Alloy Steel Gear Committee, and chairman of the Carbon and Alloy Steel Helical Spring Committee of the American Society for Steel Treating; is a member of Committee A-1 and Sub-Committee A-6 of the American Society for Testing Materials; is a member of the Executive Committee, Metallurgical Committee, Railway Gear and Pinion Committee (Chairman), Representative of A. G. M. A. Metallurgical Committee on the Iron and Steel Division S. A. E. of the American Gear Manufacturers' Association.

Mr. Phillips is on the Advisory Committee of the School of Business Administration of the University of Pittsburgh, having taken an active interest in educational work.

PRESS COMMENTS ON THE CONVENTION AND EXPOSITION

IRON Trade Review, in an eight-page review of the Ninth Annual Convention and Exposition of the American Society for Steel Treating held in Detroit, September 19 to 23, 1927, says in part in its September 29 issue, that—

"New records again were established during the ninth annual convention and exposition of the American Society for Steel Treating held at Detroit last week. With three other technical societies holding simultaneous conventions in that city and participating in the program of National Metal Week, the results were profitable to all. Official attendance at the Steel show was 61,580. Members of the society totaled 2533, or approximately 55 per cent of the total membership. Floor space at Convention Hall was 93,000 square feet, or 16 per cent larger than the 80,000 feet at last year's exposition in Chicago.

"Technical sessions were conducted at the Hotel Statler morn-

ing and afternoon from Monday through Friday, except Wednesday afternoon, when a joint session with the Institute of Metals was held at the Book-Cadillac. Attendance was unusually good, averaging between 400 and 500 in the mornings and 200 and 300 in the afternoon. Principal subjects discussed were heat treatment, testing, iron and steel, tool steel, metallography, chromium and nickel alloys, forging, spring steel and hardness testing."

Speaking of the convention and exposition the *Iron Trade Review* editorially comments under the title "Making Metal Week Permanent" as follows:

"Once again the American Society for Steel Treating has brought to a successful conclusion an annual convention of record-breaking proportions. National Metal Week most aptly depicts the activities which took place in Detroit last week. Meeting with the society in simultaneous meetings were three other national technical organizations interested in metals, their production, fabrication and treatment, with the result that the total convention attendance was the largest gathering of metals experts ever brought together in this country or the world.

"The steel treaters may well take pride in their most recent achievement. Never before have their technical sessions been so well attended—several meetings attracting between 400 and 500. About 2533 members of the society registered a figure representing 55 per cent of the total membership. The exposition required 93,000 square feet, an increase of 16 per cent over the previous record of 80,000 feet at Chicago last year. A total attendance of 61,580 was somewhat less than at the previous show, but it was of a decidedly more interested class. Despite shorter exhibition hours than formerly, manufacturers appeared enthusiastic as to the interest which visitors showed in their products. Curiosity seekers were few.

"Setting a precedent was the fact that the convention and exposition were arranged and conducted without assistance of local committees, all details being handled by the society's national office. Two local members merely aided in advisory capacity. This conservation of time for members of the local chapter is to be recommended highly and is a plan which other technical societies will do well to investigate and adopt.

"Already arrangements are in the making for the 1928 National Metal Week in Philadelphia, and most likely the same

organizations participating this year will again join hands to carry the idea to a higher plane of service to the metal-working industries."

Iron Age

In an eleven-page survey of the exposition and convention of the Society entitled "National Metal Week at Detroit a Notable Event—Many High Grade Technical Papers—Exposition Sets New Record," the *Iron Age* of September 29, 1927, comments as follows:

"Surpassing in significance and size its previous conventions, the American Society for Steel Treating brought together a gathering of American technical men which, in a way, was epochal. It was the occasion of the ninth annual convention and exposition of the steel treaters at Detroit last week, September 19 to 23. Associated with that organization were the American Welding Society, the Society of Automotive Engineers, and the Institute of Metals, so that in all the over 3150 society members assembled there included 2533 steel treaters, 425 members of the welding society, 105 nonferrous men and about 100 automotive engineers. The steel treaters' registered attendance was approximately 55 per cent of the total membership.

"A high standard characterized the technical programs. Several new developments in metallurgy and heat treatment were made public.

"Imposing in its diversity, comprehensiveness and size was the Steel and Machine Tool Exposition, to be known hereafter as the National Metal Exposition.

"No former exposition of the society has equalled the one last week at Detroit. Both the magnitude and diversity of exhibits were the features, as well as the progress reported visibly in many lines. The floor space actually rented was 93,000 square feet against 87,000 square feet in Chicago last year. The arrangement, however, surpassed in convenience and in perspective more recent displays. With nearly 300 exhibitors, many of them new ones, it is possible here only to give those who were not present a general review of the exposition as a whole. The show has reached such proportions that detailed reports are not feasible.

"Marked interest was manifested in all the technical sessions of the steel treaters, both as to attendance and discussions. In

some cases there were 400 to 500 present, particularly at the opening session and at the steel melting session. Viewing the program as a whole, there were two features: Papers dealing with steel melting and with tool steels. Besides these, the various sessions included many heat-treating papers and special subjects in which heat treatment is a factor. Of the forty-four papers, only some of the important ones can be reviewed in this report of such a stupendous program."

American Machinist

In a four-paged review of the activities of the ninth annual convention of the Society the *American Machinist* comments as follows:

"Almost every operation on steel was included in the exhibits of the ninth annual Steel and Machine Tool Exposition, held in Detroit, September 19 to 23, under the auspices of the American Society for Steel Treating. More than 300 exhibitors occupied 93,000 feet of floor space. Steel, from its raw state to its application in finished form to such products as airplane engines and automobiles was shown. Machine operations, forging operations, heat-treatment, metal testing, welding, cutting and material handling were demonstrated. Two universities exhibited the work of their engineering and metallurgical departments.

"A greater amount of the equipment was in actual operation than was the case in past exhibitions by the steel treaters. Exhibitors seemed also to have better realized the value of motion pictures which were frequenty used to show operations that could not be demonstrated in an exhibit. The exhibits included also a racing car, a passenger chassis and an airplane fuselage, as well as airplane engines, in order to show where steel is used in their construction. Automobile parts and a body were exhibited to show some of the work done in car fabrication.

"An added feature of the exposition was the official participation of the American Welding Society and a larger amount of welding equipment was shown than has been previously exhibited. Manufacturers of this type of equipment showed both gas and electric welding apparatus. As in past years, the Society of Automotive Engineers held technical sessions."

THE NINTH ANNUAL CONVENTION AND EXPOSITION OF THE AMERICAN SOCIETY FOR STEEL TREATING DETROIT, SEPTEMBER 19, 1927

BIGGER and better would be the proper words to describe the Ninth Annual Convention and Exposition of the American Society for Steel Treating held in the convention city of Detroit, the week of September 19, 1927. Never before has the Society had as large and diversified an exposition and never before have the technical sessions been of higher caliber. Meeting simultaneously with the American Society for Steel Treating, were three other technical societies, the American Welding Society, the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers and the Society of Automotive Engineers, with a combined registration of more than 3150 members who participated in the programs of National Metal Week.

The registration of members of the individual societies included 425 members of the American Welding Society, 105 members of the Institute of Metals, and 100 members of the Society of Automotive Engineers and 2533 members of the American Society for Steel Treating which is 55 per cent of the total membership of the society.

To say that the exposition and conventions were a success would be putting it mildly. The exposition located in the spacious Convention Hall was the largest in point of floor space ever occupied by exhibits of the National Steel and Machine Tool show. The diversity of products displayed and the interesting and novel exhibits made this year's show an outstanding success. With 93,000 square feet of floor space occupied by more than 300 different exhibits as compared with the 87,000 square feet occupied in Chicago it surpassed the show of last year. It is interesting to note that the exposition in Detroit this year was as much larger than the exposition in Chicago last year as was the entire exposition held in Chicago in 1919, the first one arranged for by this Society.

This year the American Welding Society combined their welding exhibit with that of the National Steel and Machine Exposition, augmenting both their own exposition and that of the Steel Show. We are pleased to state that the American Welding Society will again take part in the exposition of the American Society for Steel Treating to be held in Philadelphia the week of October 8, 1928,

which will be known hereafter as the National Metal Exposition.

Each of the four co-operating societies held technical sessions throughout the week. The Institute of Metals and the American Welding Society held their sessions at the Book-Cadillac Hotel while the Society for Automotive Engineers and the American Society for Steel Treating held their meetings at the Hotel Statler. In all, some 65 technical papers were read before these four societies, 46 of which were on the program of the American Society for Steel Treating.

A very happy relationship has existed between the American Society for Steel Treating and the three other societies meeting with us in Detroit, and it is our hope that next year these societies will again hold their meetings with us in Philadelphia.

In order that those members of the society who were unable to be in Detroit during the 1927 convention of the society may have a glimpse of what happened a considerable amount of space in this issue of TRANSACTIONS is being devoted to a review of the activities of the week of September 19, 1927. The report is arranged in chronological order.

The exposition was open each day from 12:00 noon to 10:00 P. M. with the exception of Tuesday and Thursday, on which days the exposition closed at 6:00 P. M.

All of the technical sessions of the American Society for Steel Treating were held in the Ball Room of the Statler Hotel.

There were nine sessions arranged for by the American Society for Steel Treating and a tenth session held Wednesday afternoon in the Italian Garden of the Book-Cadillac Hotel arranged for by the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers. This session was a joint session between the Institute and the American Society for Steel Treating, but was entirely planned for by the Institute.

The technical sessions were unusually well attended, there being between 400 and 500 present at practically every session. In accordance with the method of providing an accurately arranged time schedule as inaugurated two years ago in Cleveland all papers and discussions were held rigidly to the time alloted for each. This scheme has worked out admirably and has met with unanimous approval.

MONDAY, SEPTEMBER 19

The first technical session started at 10:00 A. M. Monday, Sep-

tember 19, and was called to order by W. B. Coleman, Chairman of the Meetings and Papers Committee, who introduced E. J. Hergenroether, Chairman of the Detroit Chapter of the American Society for Steel Treating, who presented a short address of welcome on behalf of the Detroit Chapter. Mr. Coleman then presented President J. Fletcher Harper, who responded to Mr. Hergenroether's welcome. Following this, J. L. McCloud was introduced as Chairman of the Technical Session, and E. J. Hergenroether as Vice-Chairman.

Five papers were scheduled for presentation as follows:

10:00—10:35 A. M.—*Deep Etch Test for Iron and Steel*—H. G. Keshian, Chase Metal Works, Waterbury, Conn.

10:35—11:10 A. M.—*Aircraft Metallurgy*—H. C. Knerr, Consulting Metallurgist, Philadelphia.

11:10—11:30 A. M.—*Furnace Development in Heat Treating and Forging*—W. M. Hepburn, Surface Combustion Company, Bronx, N. Y.

11:30—12:00 A. M.—*Hardening by Re-Heating After Cold Working*—M. A. Grossmann and C. C. Snyder, Central Alloy Steel Corp., Canton, Ohio.

Patenting of Steel—J. S. G. Primrose, Metallurgical and Testing Engineer, Manchester, England, (By Title)

Each of these papers was presented by its respective author except in the case of the fourth and fifth papers. Mr. Snyder presented his joint paper with Mr. Grossmann, and the fifth paper by J. S. G. Primrose was presented by title. Each of the papers was held closely to the time schedule allotted and considerable written and oral discussion followed the papers.

The second technical session was called to order at 2:00 P. M by Professor H. F. Moore, the Chairman and R. R. Moore as Vice-Chairman. Five papers were scheduled for presentation, which are as follows:

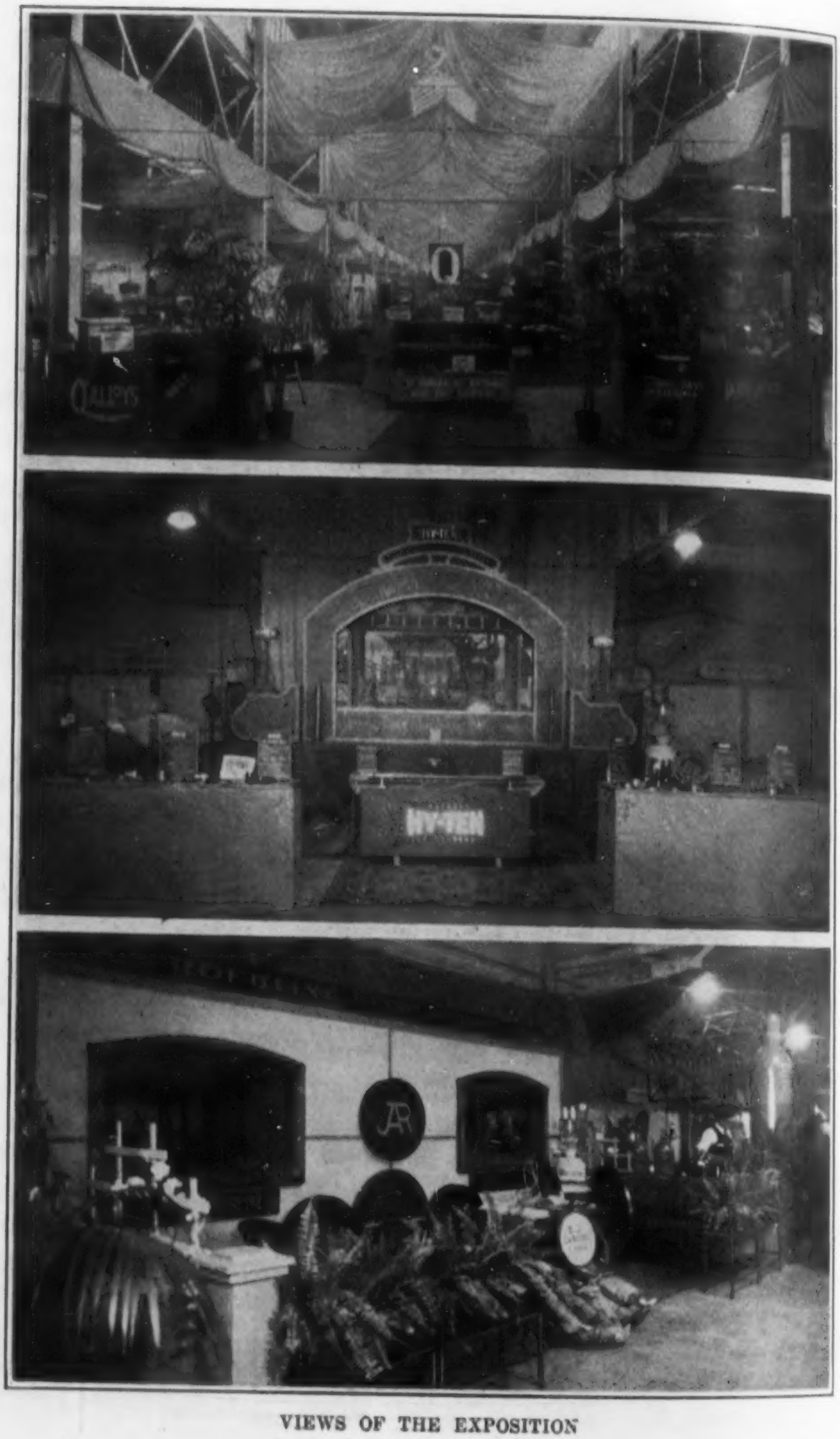
2:00—2:20 P. M.—*A Critical Study of the Bend Test as Applied to Iron and Steel*—A. B. Kinzel, Union Carbide and Carbon Research Laboratories, Long Island City, N. Y.

2:20—2:50 P. M.—*Gas Carburization of Steel*—R. G. Guthrie and Dr. O. J. Wozasek, Peoples Gas Light and Coke Company, Chicago.

2:50—3:20 P. M.—*Carburizing Iron by Mixtures of Hydrogen and Methane*—W. P. Sykes, General Electric Company, Cleveland.

3:20—3:45 P. M.—*Fatigue Tests of Carburized Steel*—H. F. Moore and N. J. Alleman, University of Illinois, Urbana, Ill.

3:45—4:10 P. M.—*Studies of Normal and Abnormal Carburizing Steels*—O. E. Harder, L. J. Weber and T. E. Jerabek, University of Minnesota, Minneapolis.



VIEWS OF THE EXPOSITION

As in the case of the morning session, much valuable written and oral discussion was presented. All of this discussion will be printed in TRANSACTIONS at the time of the publication of the respective papers. This applies likewise to all of the papers presented throughout the week.

TUESDAY, SEPTEMBER 20

The third technical session of the Convention was called to order by Chairman Radclyffe Furness, assisted by Vice-Chairmen Martin Schmid and R. H. Patch, at 10:00 A. M. Four papers being scheduled for presentation as follows:

10:00—10:30 A. M.—*Steel Melting Practice for Large Ingots and Heavy and Light High Grade Castings*—W. H. White, Duquesne Steel Foundry Company, Coraopolis, Pa.

10:30—11:00 A. M.—*The Melting or Molten Stage of Steel Manufacture with Particular Reference to the Deoxidizing, Refining and Contamination Phases*—G. A. Dornin, The Gathmann Engineering Company, Baltimore.

11:00—11:30 A. M.—*Armco Ingot Iron*—R. L. Kenyon, American Rolling Mill Company, Middletown, Ohio.

11:30—12:00 A. M.—*Segregation of Dissolved Elements and its Influence upon Carbon Distribution in Steel*—E. G. Mahin and H. J. Dillon, University of Notre Dame, Notre Dame, Ind.

Following each paper, both written and oral discussion was presented—this session proving to be highly interesting and instructive to the steel makers—there being much interest shown in the session as a whole.

The Tuesday afternoon session was presided over by Dr. J. A. Mathews as Chairman, and B. F. Shepherd as Vice-Chairman. The meeting was called to order at 2:00 P. M. Five papers were scheduled for presentation, all of which were presented by their respective authors. The papers presented are as follows:

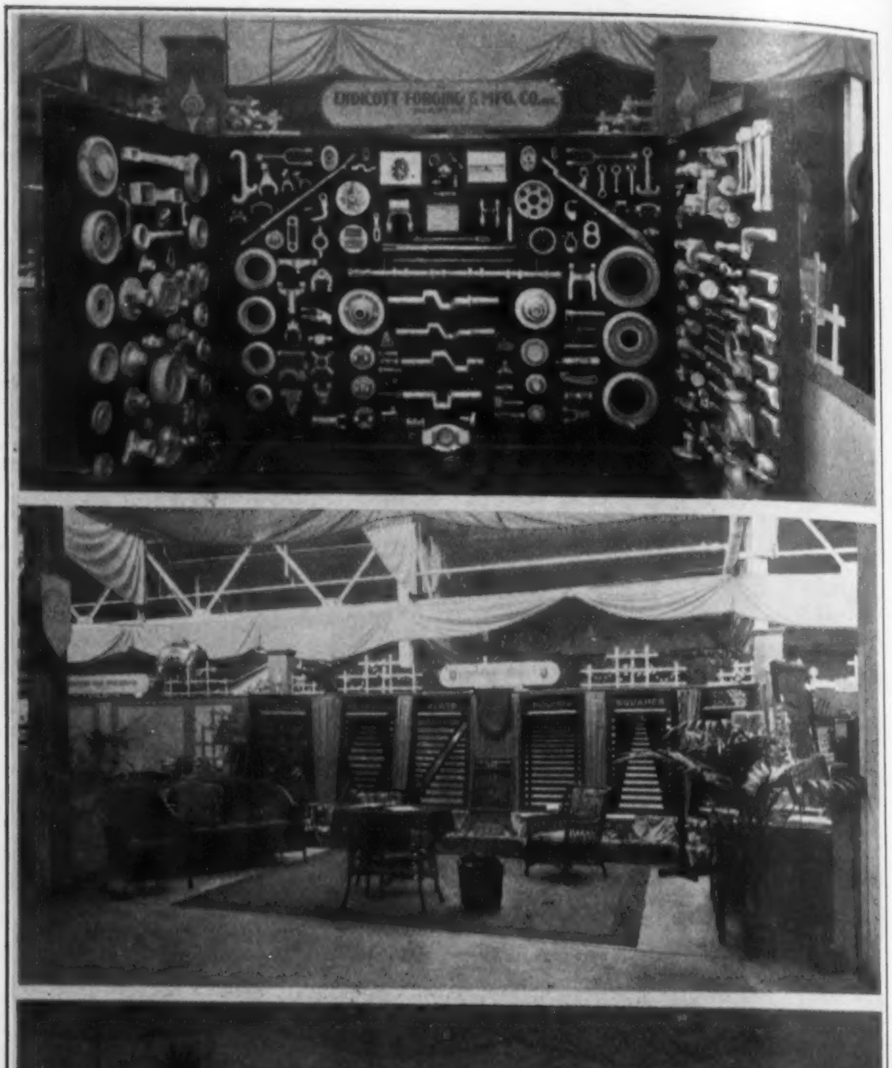
2:00—2:20 P. M.—*The Development of High Speed Steel Hacksaws or Cutting off Saws*—H. B. Allen, Henry Disston & Sons, Inc., Philadelphia.

2:20—2:50 P. M.—*A High Temperature Quenching Treatment Applied to Cold Heading Ball Dies of Plain Carbon Tool Steel*—F. L. Wright, Atlas Ball Co., Philadelphia.

2:50—3:20 P. M.—*Evaluating Quality in Heat Treated High Speed Steel by Means of the Milling Cutter*—J. B. Mudge and F. E. Cooney, Western Electric Company, Chicago.

3:20—3:45 P. M.—*On the Constitution and Properties of Hardened Steel*—W. P. Sykes and Zay Jeffries, General Electric Company, Cleveland.

3:45—4:15 P. M.—*Testing Automobile Body Sheet Steel*—Joseph Winlock and George L. Kelley, Edward G. Budd Manufacturing Co., Philadelphia.



VIEWS OF THE EXPOSITION

The discussions following each of these papers will be printed later in TRANSACTIONS.

MIDNIGHT THEATER PARTY

At 11:00 P. M. Tuesday evening about 2000 members and guests of the Society assembled at the State Theater and were entertained by a very delightful vaudeville and movie show. The entire theater had been reserved for the members of the Society and their guests. This feature was somewhat different from that of previous years, inasmuch, as both ladies and men attended the theater party, whereas, in previous years, the party had been of the smoker type of entertainment and attended only by the men.

WEDNESDAY, SEPTEMBER 21

Wednesday morning, September 21, as has been the custom of several previous years, was devoted to two features, the first of which was the annual meeting of the American Society for Steel Treating, at which time the President, Secretary and Treasurer of the Society presented their annual reports to the membership, and the second a technical session. Each of the officer's reports is printed in full as follows:

THE PRESIDENT'S ANNUAL ADDRESS

J. FLETCHER HARPER, *President*, 1927

IT gives me great pleasure to comply with our Constitution and present the report of the activities of the society to the members.

The society has prospered during the last year, its scope has been enlarged and its activities have been increased through the hearty support of the members. The chapter form of government with the National Office as a means of binding the individual units has proved its success. We have added since our last annual meeting five new chapters and groups, namely: Southern Tier, Dayton, Columbus, Canton-Massillon and Notre Dame. To these new-comers we wish to extend a hand of welcome and to express confidence in their success.

Our growth into new fields should continue and progress just as rapidly as the localities develop sufficient members with interest in our activities. It, however, is my belief that new sections should be formed under the group plan until sufficient staple membership has been proven by a year or more operation. The development of strong meetings with live interest is the keynote to the success of our chapters.

At this meeting your Board of Directors, by petition of the mem-

bers, has added two names to the roll of honorary members; Dr. W. R. Whitney, Director of Research of the General Electric Company and Charles F. Kettering, Vice-President and Director of General Motors Research Laboratories.

The activities of these two men are similar, while the industries they represent are two of our greatest. Their work and that of their laboratories has greatly advanced our knowledge of metals; and we are greatly honored to have them among our membership.

The past year has seen the passing of one of our honorary members, Judge Elbert H. Gary. His personality is written everlasting in the steel industry; however, we mourn his loss.

The works of the individual are the reasons for the success of this society. The untiring efforts of the various members acting in their chapters and on various committees have been remarkable; and I wish to express my appreciation to them.

It would be impossible to mention all of the wonderful co-operation which has been shown during the past year; but I do wish to mention some examples.

The Finance Committee under the leadership of our National Treasurer, Dr. Zay Jeffries, has worked up budget and expense figures and invested your money in a most capable manner, as you will see by the Treasurer's report.

The Publication Committee, under Prof. H. M. Boylston, has had several meetings and have labored to make the TRANSACTIONS better and in accordance with the views of the majority of the members. The increase of practical articles and improved form are due to this Committee and our Editor, Ray T. Bayless.

The ever increasing work heaped upon the only too willing shoulders of Mr. Bayless, has caused your Board to heed the suggestion of the Publication Committee, and add Robert M. Tripp to the editorial staff.

The unsurpassed excellence of the papers and diversified program at this Convention is due to the work of the Meetings and Papers Committees, and its chairman, W. B. Coleman.

The Constitution and By-Laws Committee, with S. M. Havens as chairman, have worked upon the new Constitution and By-Laws, which is to be presented later for your ratification. The change in the General Corporation Act of Ohio, effective June 9, 1927, and several obvious errors in the present Constitution made it appear wise that the changes be made at this time. It might be well to touch upon one or two of these outstanding changes.

The elimination of the Associate Member is the one change which is probably the most radical. The Associate Membership was a class which was established in the youth of our organization, when it was thought that this type of member might get in control of the Society and use it to further his own ends. This fear was unfounded and has been proven so for some time. The Associate Members are very much in the minority, while the individuals in this classification have been most valuable and active workers. Their advice, guidance and activities in office should be sought,

and not legislated against. The difficulty of classification and the discrimination in the matter of dues should be eliminated. It was for these reasons that this proposed change was suggested.

The combination of the Publication and the Meetings and Papers Committees is a change for better organization and elimination of divided authority; in order that a paper which is acceptable for a meeting will be acceptable for publication. The present chairman of the Meetings and Papers Committees, W. B. Coleman, has been appointed a member of the Publication Committee so that his valuable experience will not be lost.

The other changes, have been amply explained in the revisions sent to each member; however, I sincerely hope that the members will appreciate and acknowledge the time, care and study that the Committee has given in the preparation of this revised Constitution and By-Laws.

The Recommended Practice Committee under the management of W. J. Merten and the able assistance of J. E. Donnellan, has prepared a number of recommended practices and data sheets. The endeavors of this committee have been furthered by sub-committees and individual members. The work of this Committee is one of vital interest to the Society and to Industry; and the support of every member is asked in order that corrections of existing data sheets and new data sheets can be prepared.

A sub-committee of the Recommended Practice Committee on Heat Treatment Definitions worked as a joint committee with members of the Society of Automotive Engineers and the American Society for Testing Materials. This joint committee formulated a set of tentative definitions which have been accepted by the three Societies. Your Society deserves great credit for seeing the need for these Definitions and for fostering and carrying through to completion this work.

Our relations with other technical Societies have been most cordial, as manifested by this joint committee with the American Society for Testing Materials and the Society of Automotive Engineers.

The assistance of a committee of the Institute of Metals has been obtained to undertake the formulation of nonferrous data sheets The cooperation of this nonferrous technical group in this work is most gratifying.

The American Institute of Mining and Metallurgical Engineers extended an invitation to us to participate in their February Meeting, which was greatly appreciated and attended by a large number of our membership.

During the present week three other Societies are holding meetings: The American Welding Society, The Institute of Metals Division, American Institute of Mining and Metallurgical Engineers, and the Production Meeting of the Society of Automotive Engineers. We bid them welcome and sincerely hope that the pleasant relations which exist between the Societies shall continue. The sessions of Societies having allied interests in iron and steel, at the same place and time, is for simplification and conservation of time for the individual.

There have been several policies adopted by your Board of Directors, which are for better organization. The practice of having two Sectional Meetings has been eliminated and one Semi-Annual Meeting substituted.

Montreal has been selected for the next Semi-Annual Meeting with the dates of February 16 and 17, 1928.

The National Office will have full charge and be responsible for all arrangements for both the Annual Meeting and Convention, and the Semi-Annual Meeting. The members of the local chapter will not be asked to give up time and energy as in the past. Demands upon the local membership from their business for such meetings appeared to your Board to be an injustice. However, several local members are appointed to act as representatives of the Board in purely an advisory capacity.

This plan has been in force at Detroit and our appreciation is expressed to J. M. Watson and Robert Atkinson for the assistance and counsel they have rendered.

The Annual Convention and the National Metal Exposition will be held next year in Philadelphia the week of October 8, 1928.

There have been several comments in the past about conflicts with other meetings and expositions, and your Board endeavored to thoroughly canvass the situation and select a date when no conflict would occur. While the exact dates of several contemplated shows could not, or had not, been determined; the week of October 8, 1928, when choosen, appeared to offer no paralleling of allied activities.

The Philadelphia exhibition floor space available is less than we have had for the past two years. This splendid exposition in Detroit has exceeded the Chicago show by 6000 square feet while the available area at Philadelphia is 17,000 square feet less than Detroit. This reduction of floor space is not desirable; but it was thought that the meetings should be made more readily available to new localities and that exhibitors should be given the opportunity to show to these new localities.

The educational advancement of our members has always been one of the leading aims of the Society; and while the execution of this purpose should be largely through the local chapters, it was felt that the National Organization should aid in a general way.

The Society has obtained, in co-operation with the Engineering Extension Department of Purdue University, the services of John F. Keller until the first of next year.

Mr. Keller is giving a course of six lectures in industrial centers where sufficient enrollment can be secured. Five of these courses have been started and are meeting with most hearty approval from both the executives and shopmen.

The enlargement of the scope of our Society has been great and I want to express my appreciation to your Board of Directors who have so freely given of their time and energy. Their efforts are not always seen by the large body of the membership, but I wish to assure you the splendid results accomplished are due to them.

Our National Office is a loyal, faithful organization which is headed by the greatest Society Secretary in this country, William H. Eisenman. Their endeavors and those of your Directors are for the greatest good for the membership as a whole. They invite your criticism and appreciate your approval.

The loyal, unselfish service of the membership should cause the Society to reach new heights in technical developments and service to the industry.

ANNUAL REPORT OF THE SECRETARY

WILLIAM HUNT EISENMAN, *Secretary*

HONORARY MEMBERS

At the annual banquet at Chicago last year Elbert H. Gary and Charles M. Schwab accepted election and certificates to Honorary Membership in the A. S. S. T. Mr. Schwab was present in person to receive his certificate; but, due to illness, Judge Gary's certificate was accepted by his authorized representative, Mr. E. J. Buffington, president of the Illinois Steel Company.

It is with deep regret that the Society records the death of Judge Elbert H. Gary. His splendid achievements and activities will be a source of inspiration of our membership and we have been pleased to count him among our honorary members, even though for a brief time.

HENRY MARION HOWE MEDAL

The Henry Marion Howe Medal was awarded for the 4th time at the annual banquet held at Chicago last year, the 1926 recipient being Dr. Frederick C. Langenberg. Dr. Langenberg's paper, entitled *Effect of Cold Working on the Strength of Hollow Cylinders,* had been judged the paper of highest merit published in the TRANSACTIONS during the 12 months from August, 1925, to August, 1926.

E. D. CAMPBELL MEMORIAL LECTURE

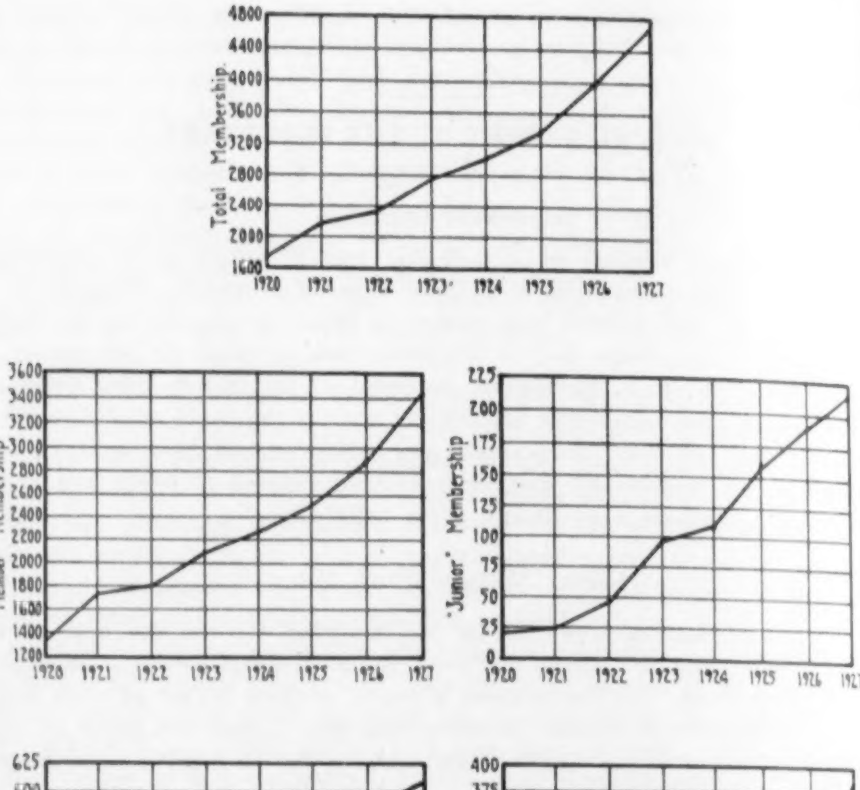
Dr. William Minot Guertler, director of Technische Hochschule, Charlottenburg, Berlin, Germany, delivered the Campbell Memorial Lecture at Chicago on Wednesday, September 22, 1926. After the close of the convention Dr. Guertler made a number of guest appearances before institutions of learning and chapters of the Society.

MEMBERSHIP

The A. S. S. T. on August 31, 1927, had a membership of 4653. Of this number 3436 or 73.5 per cent were of member classification; 608 or 13.1 per cent of associate classification; 382 or 8.2 per cent of sustaining classification; 217 or 4.7 per cent of Junior classification; 10 honorary members and 3 founder members. The year just closed showed a net gain of 653 new members over August 31, 1926. This is 16.3 per cent increase over the preceding year. The accompanying curves show the increase in membership since 1920; the upper curve shows the increase in total membership while the four lower ones show the line of progress in the acquisition of members, juniors, associates, and sustaining members from 1920 to date.

MEETINGS OF BOARD OF DIRECTORS

The Board of Directors held three meetings during the past year as



Curves Showing the Increase in Membership of the Society from 1920 to the Present Time.

follows: Chicago, September 22, 1926; Washington, January 19, 1927; Milwaukee, May 19, 1927.

The minutes of these meetings have, according to custom, been published in the TRANSACTIONS.

NEW CHAPTERS AND GROUPS

The Montreal Group organized in 1926 was by action of the Board of Directors, promoted from the standing of a group to that of a chapter. New chapters and groups were organized as follows: Southern Tier; Dayton;

Columbus; Canton-Massillon; and Notre Dame. The greater portion of the field work for the organization of these units were performed by Assistant Secretary H. K. Briggs. The directors are conscious of the fine spirit of co-operation given to the National Office in the preliminary work by individuals and industries in these centers. Each of the new chapters is in healthy condition and has at this early date demonstrated its ability to function in a manner in keeping with the high standard already set by the older chapters.

Table I

A. S. S. T. Membership 1920-1927

	Members	Associate	Sustaining	Junior	Honorary	Founder	Total Membership	Increase	Per Cent Increase
1920	1349	302	50	21	2	0	1724	...	....
1921	1742	341	56	25	4	0	2168	444	25.7
1922	1798	375	86	48	6	0	2313	145	6.7
1923	2048	400	191	99	6	2	2746	433	18.7
1924	2224	476	209	109	6	2	3026	280	10.2
1925	2452	500	243	160	6	2	3363	337	11.1
1926	2916	580	303	190	8	3	4000	637	18.9
1927	3436	608	382	217	11	3	4653	653	16.3

Chapters and Groups

The past year has been a very successful one for the chapters. All are in good financial condition and had splendid meeting activities. Excellent programs had been arranged, and in the majority of instances were planned well in advance and contributed to a balanced program dealing with the subjects in which the particular group was most interested. The chapters continue to take great interest in the activities of the National Office and have been of valuable assistance in the support of the national committees in the discharge of their duties. The chapters continue to operate very successfully from a financial point, many having bond investments and savings accounts.

The total assets of the chapters at the close of the fiscal year June 1, 1927, was $17,738.34.

Educational Activities

It was a pleasure to report last year the educational activity of a number of the chapters. This year Philadelphia, Golden Gate, Providence, Cincinnati and Montreal have all had educational courses in operation. In every instance the results accomplished have been most encouraging and preparations are being made for continuing this work.

Pittsburgh, Detroit, North West and Worcester co-operated with local institutions in the presentation of metallurgical courses. The results were well worth while.

Transactions

Table II shows the total editorial production of the first 12 volumes of the Transactions—11,116 pages. The number of pages, however, in Volume 12 is estimated.

During the past year TRANSACTIONS has contained 84 papers—a total of 2114 pages. A division compiled by the Publication Committee in placing the papers into three classes—Practical, Semi-Technical and Technical, shows that 716 pages or 34 per cent were of the Practical class; 375 pages of 17.7 per cent were of a semi-technical nature, with 451 pages or 21.3 per cent technical.

In addition to the percentages as indicated for the Practical, Semi-Technical and Technical, TRANSACTIONS printed 572 pages or approximately 25 per cent of chapter news, editorial matter, patent reviews, engineering index, news of the society and items of interest.

We feel that all of our members of the Society appreciate the high standing that is being obtained for the TRANSACTIONS as well as its constant improvement from year to year.

Table II
Total Editorial Production
Transactions

Vol. 1	840 pages
Vol. 2	1,238
Vol. 3	1,000
Vol. 4	752
Vol. 5	642
Vol. 6	816
Vol. 7	816
Vol. 8	892
Vol. 9	992
Vol. 10	1,036
Vol. 11	1,042
Vol. 12	1,050
Total	11,116

Data Sheets

	Pages	Subjects
1924	116	17
1925	129	21
1926	114	13
1927	86	10
Total	445	61

Editor Ray T. Bayless and his assistant, Robert M. Tripp, have had the constant advice and splendid co-operation of Professor H. M. Boylston, chairman of the Publication Committee, and also the able members of that committee.

ANNUAL REPORT OF THE RECOMMENDED PRACTICE COMMITTEE

The Recommended Practice Committee of the A. S. S. T. has had under its supervision during the last year 13 sub-committees. The sub-committees have either completed their work or are now actively engaged in preparing recommended practices for the heat treatment of various articles.

The Committee has held two meetings so far this year. The first one was held in Washington during the Winter Sectional Meeting; the second was

held in Milwaukee during the Spring Sectional Meeting. At these meetings various data sheet subjects were considered and problems assigned to the sub-committees. When J. Fletcher Harper took office as president, W. J. Merten was appointed chairman of the Recommended Practice Committee. At this same time R. S. Archer was also appointed to membership on the committee. The following is a report of each sub-committee and the work accomplished on data sheets during the last year.

Sub-Committee for the Heat Treatment of Tool Steel

The sub-committee for the Heat Treatment of Tool Steel, with J. P. Gill as chairman, has prepared during the last year three tentative recommended practices as follows:

1. Tentative Recommended Practice for the Heat Treatment of Plain Carbon and Alloy Steel Die Blocks.
2. Recommended Practice for the Heat Treatment of Shear Blades.
3. Recommended Practice for the Heat Treatment of Dies for Die Castings.

The first recommended practice has been issued to the members in data sheet form. The other two recommended practices are now in the hands of the Recommended Practice Committee and will probably be approved for issuing in data sheet form early this fall.

The Sub-Committee on Tool Steel is now preparing a Heat Treating Practice for Blanking Dies and Punches.

Sub-Committee on Relation of Design to Heat Treatment

This committee was appointed a few months ago so has not had an opportunity to complete its work. A. H. d'Arcambal, chairman of the committee, has requested each member of the sub-committee to forward to him such information and data as they may have available on the relation of design to heat treatment. After Mr. d'Arcambal has secured sufficient data a tentative report is to be prepared, after which a committee meeting will be held to make the final revisions and put the report in such condition for consideration of the Recommended Practice Committee.

Sub-Committee on Measuring Case Depth

The sub-committee on the Measuring of Case Depth has been in existence for at least three years, but considerable difficulty has been encountered by the committee in arriving at definite conclusions. Last year the committee prepared a report, but at that time was unable to definitely recommend suitable methods for measuring case depth. S. P. Rockwell, chairman of the committee, is at present working with some of his members in carrying out experimental work, which he hopes will help the sub-committee to arrive at definite conclusions and prepare a practice on the subject of measuring case depth.

Sub-Committee on the Heat Treatment of Water and Oil Hardening Gears

This sub-committee has had two meetings and has about completed a heat treating practice for gears designed for water and oil hardening. There is still some work to be done on this subject by the sub-committee before the

report is submitted to the Recommended Practice Committee for final consideration. The chairman of this committee is C. P. Richter.

Committee on Hardness Testing of Metals

The Committee on Hardness Testing has been engaged in performing some experimental work on the effect of the time involved in making Brinell hardness tests. This work has been performed by the majority of members on the committee, and has been supervised by chairman, H. M. German.

Mr. German has prepared a report which is to be submitted to the Recommended Practice Committee early this fall. This committee also assigned to A. L. Davis, of the Scovill Mfg. Co., a member of the committee, the problem of preparing new data sheets on the Rockwell hardness tester. This manuscript has been submitted to every member of the Hardness Testing Committee and is now being revised for the consideration of the Recommended Practice Committee.

Sub-Committee on the Mechanism of Cementation

This committee, with Dr. V. N. Krivobok as chairman, has not been able to carry out its original plan, namely of preparing data sheets covering the nitrogenizing of steel. This problem was assigned to the sub-committee by the Recommended Practice Committee, but the assignment was made when interest was first developed in the nitrogenizing process as introduced into this country by Dr. Frye.

It appeared that it was too soon for a sub-committee to accomplish any work along this line. The Recommended Practice Committee has, therefore, altered the problem somewhat and has requested the sub-committee to prepare data sheets on carburizing when using a gas or solid carburizer, incorporating such information as the chemical reactions, carbon penetration and structural conditions.

Sub-Committee on the Heat Treatment and Care of Crane Chains

This committee, with A. V. deForest as chairman, has completed its work and a report was recently submitted to the Recommended Practice Committee. The majority of the members of the Recommended Practice Committee approved of issuing the report in tentative form. A few points, however, on the heat treating data are still pending revision, but this will be taken care of early this fall, at which time it is expected the report will be ready for publication.

Sub-Committee on the Heat Treatment of Wrought Aluminum Alloys

This committee has completed its work and the manuscript entitled "Heat Treatment of Wrought Aluminum Alloys of High Tensile Strength" has been accepted by the Recommended Practice Committee. This material has been set in type and is scheduled for distribution to the members in September. This sub-committee has been discharged from active duty because of other arrangements made for the preparation of data sheets on nonferrous subjects.

Sub-Committee on the Heat Treatment of Carbon Steels S. A. E. Series

This committee, with A. E. Buelow as chairman, has prepared a Heat Treating Practice on the S. A. E. Carbon Steels as used for structural purposes. This report was recently submitted to the Recommended Practice Committee and has been approved for issuing in data sheet form.

Sub-Committee on the Heat Treatment of Spring Steel

This sub-committee was in existence two years ago, but upon completion of its work of preparing a recommended practice on Plain Carbon and Alloy Spring Steel was discharged from active duty. During the past year, however, the committee was reappointed and was assigned the problem of revising its tentative practice and preparing a new practice on the heating and forming of springs.

The sub-committee is concentrating its efforts on helical springs as used by the railroads. This problem will take considerable time and it is not expected that a report will be out for several months.

Sub-Committee on the Heat Treatment of Spline Shafts

This is a new committee that has recently been appointed, but work is in process of preparation, and it is hoped that sufficient information will be secured so that a sub-committee meeting can be held early this fall.

Joint Committee on Heat Treating Definitions

The Joint Committee on Heat Treating Definitions is made up of representatives from the S. A. E., A. S. T. M. and the A. S. S. T. The personnel of this joint committee representing the A. S. S. T. is J. Fletcher Harper, Bradley Stoughton, W. J. Merten.

The Joint Committee several months ago prepared a set of heat treating definitions. These definitions have since been in the hands of the Executive Committees of the three Societies represented.

All Societies have reported that the definitions are approved in tentative form so the report of the Joint Committee has been released for general distribution and for publication in the various papers of the three Societies. These definitions have been printed in the TRANSACTIONS of the Society and are to be issued in data sheet form within a short time.

Sub-Committee on the Heat Treatment of Steel Castings

This committee, with A. N. Conarroe as chairman, has prepared a tentative Recommended Practice for the Heat Treatment of Steel Castings. This practice includes the annealing, normalizing and quenching of steel castings, considering only those castings of plain carbon steels.

The report from the sub-committee has been accepted by the Recommended Practice Committee so will be issued in data sheet form within a short time. This sub-committee is now planning to prepare a heat treating practice for alloy castings.

Institute of Metals Committee on Nonferrous Data Sheets

The Recommended Practice Committee has, at various times, considered the problem of preparing data sheets for the A. S. S. T. HANDBOOK on Nonferrous subjects, but recently co-operative arrangements have been worked out whereby the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers is going to have committees prepare all the data sheets on nonferrous subjects.

In the event that the Recommended Practice Committee is interested in having nonferrous sheets prepared, the request is to be referred to R. S. Archer, chairman of the Institute of Metals Committee, for the consideration of his committee.

Although the Recommended Practice Committee is not directly interested in supervising the preparation of these sheets, the manuscripts prepared on nonferrous subjects are to be submitted to at least a few of the members of the Recommended Practice Committee.

Mr. Archer's committee is at present preparing data sheets on bearing metals, and plans are to be formulated for the preparation of equilibrium diagrams. The first problem has been assigned to Jerome Strauss, and is now in process of preparation.

Report on Data Sheets

The following data sheets have been issued for the A. S. S. T. HANDBOOK during the last year:

		Pages
1.	*What Should a Man with only one Pyrometer do in case of Trouble*	12
2.	*Tentative Recommended Practice for the Heat Treatment of Plain Carbon and Alloy Steel Die Blocks*	14
3.	*Data on Fuels*	2
4.	*Coloring Steel Articles*	7
5.	*Molybdenum as an Alloying Element in Steel*	10
6.	*Recommended Practice for the Heat Treatment of Finishing Steel (Advanced to Standard)*	2
7.	*Recommended Practice for the Carburizing and Heat Treating of Camshafts. (Advanced to Standard)*	3
8.	*Weights of Alloys and Metals*	2
9.	*Mechanical Methods for Cleaning Metals with Alkaline Solutions*	6
10.	*Tentative Recommended Practice for the Carburizing and Heat Treating of Piston Pins*	2
11.	*Selective Carburization of Steel*	4
12.	*Recommended Practice for the Heat Treatment of Taps and Milling Cutters. (Advanced to Standard)*	4
13.	*Cast Iron*	18
	Total Pages	86

The HANDBOOK at present contains 445 pages, on 61 subjects.

Data Sheet Manuscripts Received—in Process of Preparation

Data sheet manuscripts have been received from authors and committees on the subjects listed below. These manuscripts are either in the hands of the Recommended Practice Committee, a reviewing committee, or in process of printing.

1. *Chemical Methods for the Analysis of Steels*
2. *Tool Steel Trade Names (revised list)*
3. *Pickling*
4. *Wrought Aluminum Alloys of High Tensile Strength*
5. *Definitions and Heat Treating Terms*
6. *Tentative Recommended Practice for the Heat Treatment of Carbon Steels—S. A. E. Series*
7. *Tentative Recommended Practice for the Care and Heat Treatment of Crane Chains*
8. *Tentative Recommended Practice for the Heat Treatment of Steel Castings*
9. *Tentative Recommended Practice for the Heat Treatment of Dies for Die Castings*
10. *Design and Composition of Carburizing Boxes*
11. *Iron-Zinc System*

Data Sheets in Preparation

Authors and sub-committees are preparing for the Recommended Practice Committee data sheets on various subjects. It is not definitely known when the manuscripts on these subjects will be received, but it is planned to have data sheets issued on the following subjects:

1. *Cyaniding*
2. *Corrosion Resistant Alloys*
3. *Tempering Equipment*
4. *Silicon as an Alloying Element in Steel*
5. *Welding*
6. *Alloy Cast Irons (including composition, heat treatment, etc.)*
7. *Heat Treating by Means of the Acetylene Torch*
8. *Heat Treatment of Malleable Cast Iron*
9. *Equilibrium Diagrams for the Alloy Systems*
10. *Forgings*
11. *Chromium*
12. *Manganese*
13. *Cast Metals for Tools*

(About 6 other subjects)

It is planned to issue data sheets to the members according to the following schedule:

September: *Wrought Aluminum Alloys of High Tensile Strength.*

October: *Tentative Recommended Practice for the Carburizing of Gears, (Revised)*
Tentative Recommended Practice for Dies for Die Castings.
Recommended Practice for Non-Shrinking Tool Steel. (Advanced to Standard)

November: *Tool Steel Trade Names.*
Tentative Recommended Practice for the Heat Treatment of Shear Blades.
December: *Chemical Methods for the Analysis of Steel.*

With this schedule there will also be issued at various times other reports received from the sub-committees.

INDEX

A general index to the first 10 volumes of the TRANSACTIONS of the A. S. S. T. embracing some 12,000 pages and also volumes I and II of the *Journal* of the American Steel Treaters Society has been prepared under the painstaking and careful direction of Frank T. Sisco, McCook Field, Dayton, Ohio. By action of the Board of Directors, members were permitted to secure this index at the price of $1.00 per bound volume. The sale price of the index will be $3.00 per volume. The indexes have been mailed to the members who ordered them in advance.

1926 CONVENTION

The Chicago Convention of the A. S. S. T. again attracted world wide attention because of the splendid program of technical papers arranged for that meeting. All together there were presented 45 papers, of which 24 were preprinted. A large number of members contributed written discussions which was a very important feature. These papers have been greatly appreciated not only in their preprinted form but as they appeared later in the pages of the TRANSACTIONS.

The meeting concurrently in Chicago of the Production Meeting of the S. A. E. and the special session of the Machine Shop Practice Division of the A. S. M. E. contributed to a well rounded program.

The large percentage of members of the Society (2025) in attendance at Chicago was a topic of favorable comment. The following remarks are quoted from *Iron Trade Review:*

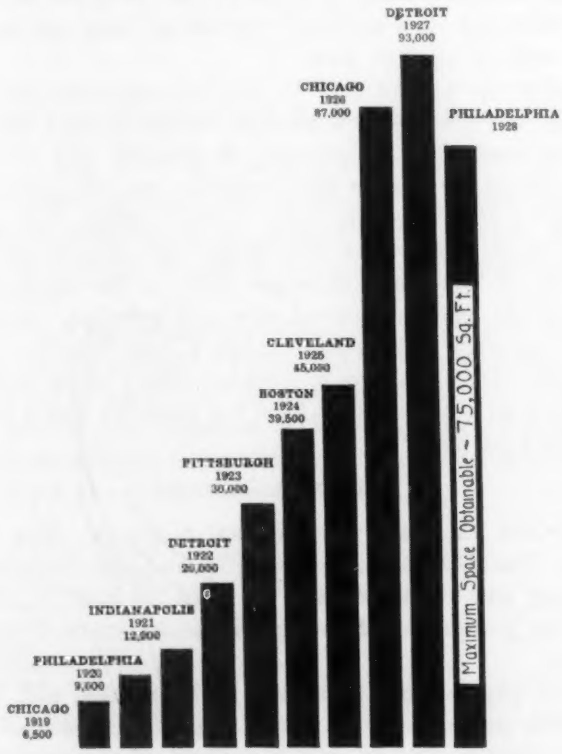
"The other phases of the convention, including the technical program, inspection trips, banquet and entertainment features, as well as the meetings of the Society of Automotive Engineers and American Society of Mechanical Engineers were run off smoothly and in a manner meriting high approval.

"Considering the meeting as a whole, it provided a wonderful inspiration for those fortunate enough to attend. It reflected the ever broadening application of metallurgy in the metal industry and served, perhaps better than any other agency, to bring together the wideflung interests responsible for making, treating, fabricating, machining and assembling steel and steel products. It breathed progress and hope for the future to every operator, metallurgist or other official or technician who participated. Aside from the commercial advantages derived from it, the meeting ranked so high in educational and inspirational value that it must be considered a banner event in the development of the steel industry."

Another comment stated: "Again a new record by the American Society for Steel Treating at its annual meeting this year. Both in its technical and exhibition phases, the eighth annual convention and steel and machine tool

exposition surpassed any previous affairs. Meeting this year at Chicago, September 20 to 24, it in a measure celebrated the eighth anniversary of its birth. In 1919, at the Seventh Regiment Armory in the same city, the first convention and exhibition of the American Steel Treaters' Society was held. This finally expanded into the present large organization, and the contrast between the imposing achievement of this year and the one seven years ago has been most striking. This story has been told many times.

"In technical offerings this year's program fully sustained the high standard set last year at Cleveland, September 14 to 18. In attendance and



Graphic Representation of the Growth of A. S. S. T. Expositions.

keen interest, the former high water marks were met. The outstanding feature was the expansion of the exposition—exceeding by nearly 100 per cent the space engaged and the number of exhibitors a year ago."

Speaking of the convention and exposition the *Iron Age* editorially comments under the title "For Better Steels" as follows:

"From the modest convention and exposition of 1919 in Chicago, the meeting of the American Society for Steel Treating in the same city last week represents an advance nothing short of phenomenal. Each year the Society has furnished a fresh text for comment on its achievements, notwithstanding that with every added year the job of exceeding itself has been more and more difficult. Naturally membership cannot continue to increase by leaps and bounds, when once the great majority of eligible men have allied

themselves with the movement. But each year has seen a healthy gain in the Society's influence, with more than 4,000 members now on its rolls, while the strength of its present appeal to collateral industries may be gaged by the figures of exposition floor space—85,000 square feet last week against 6,500 square feet seven years ago.

"From the wide range and high quality of the papers and discussions, as fully reported, it may fairly be said that this commercial expansion has not been gained at the expense of development on the technical side. While no radical departures were announced, there were interesting accounts of new and better work in lines already well pioneered. The Society's recent decision to extend its activities to nonferrous metallurgy was signalized by three excellent papers bearing on that field.

"The steel treaters have left to the organizations that for years have dealt with them the processes of iron and steel production. Yet it was inevitable that the researches of so many progressive men in the interest of a longer life and better service for steel entering into the products of the metal-working industries should reach back to the rolling mill and the melting furnace. Several of the papers at Chicago are reminders of the part the testing engineers of important railroads took in the discussions of 20 years ago that lead to the modification of rail mill practice. But the indications are that latter-day steel makers have taken a leaf from the book of the old-time rail manufacturers and to a greater extent than ever are producing steels that as they go from the mill have the qualities called for by the service to which they will be put."

Sectional Meeting

The Society last year held two sectional meetings. The Winter Sectional Meeting was in Washington on January 20 and 21, 1927, while the Spring Sectional Meeting was in Milwaukee on May 20 and 21, 1927. While the attendance at the Washington Meeting was satisfactory, it was not as heavy as at Milwaukee.

Six technical papers were presented at Milwaukee and 7 were given at Washington, which combined with plant inspection, provided very successful meetings. The chapter officers and members of these chapters discharged their duties very efficiently in making splendid arrangements for these meetings.

1926 Exposition

The Chicago Exposition was by far the largest the Society had held up to that time, occupying a total area of 87,000 square feet. The chart shown gives the growth of the exposition since 1919. The Municipal Pier leant itself very well for exhibit purposes, although the necessary decorating, remodeling, constructing of booths and installing of equipment for electrical connections, caused the expenses to be heavier than for a similar show in any other city. From the exhibitors' standpoint we found a most pleasant response as to their having been well pleased with the results they obtained and with the exception of unpleasant contact with the labor unions, considered the exposition to have maintained its usual successful standards.

1927 Exposition

The present exposition which all of you have had the opportunity to observe quite easily stamps itself as the best rounded educational exposition it has been the privilege of the Society to present. You have observed that no particular element of the metal-working or metal-treating field predominates, but that all of the activities incident to the metal industry are being most thoroughly demonstrated, so that the entire exposition presents an educational insight from the raw material to the finished product. It is interesting to note that the Detroit Exposition is he largest that the Society has ever held, exceeding by 5,000 square feet, the total space reserved for the Chicago Show.

ANNUAL REPORT OF THE TREASURER

Dr. Zay Jeffries, *Treasurer*

An unaudited profit and loss statement of the American Society for Steel Treating from January 1 to August 31 inclusive, 1927, and the balance sheet as of August 31, 1927, show a very satisfactory financial status of the Society.

The profit and loss statement shows that the income of the Society for the first eight months of 1927 was $81,346.36 and expenses were $76,795.51, leaving an excess of income over expense of $4,550.85, exclusive of the 1927 convention income and expense. The assets as of August 31, 1927, after deducting advance receipts for this year's convention were $117,702.62.

The balance sheet shows the following:

Cash Accounts:		
Commercial Account—Cleveland Trust Co.		$ 16,187.45
Savings Account—Cleveland Trust Co.		20,275.43
Savings Account—Equity Savings & Loan Co.		18,875.67
Savings Account—Union Trust Co.		20,411.70
Bond Investments		82,846.25
Accounts Receivable		11,169.47
Inventory and Office Furniture and Fixtures		6,430.69
Prepaid Expenses for 1928 Convention		30.00
Accrued Interest		100.69
		$176,327.35
A claim against these assets exists in the amount to be refunded to the chapters for dues received in August		1,155.94
		$175,171.41
There is also included in the above cash accounts the advance receipts for the present convention	$78,675.75	
less expenses paid to August 31, 1927	21,206.96	
		57,468.79
As the services to be rendered for these advance receipts have not yet been completed and the majcrity of th convention charges have not been paid, a deduction of this amount should be made and the result will give the Society's present net worth.		$117,702.62

The following comparisons with previous years may be of interest:

Amount Paid to Chapters		*Total Assets of the A. S. S. T.*	
For 1921	$ 7,244.22	As of Dec. 31, 1921	$ 16,520.90
1922	10,051.95	Dec. 31, 1922	31,391.31
1923	12,751.45	Dec. 31, 1923	46,821.30
1924	14,194.14	Dec. 31, 1924	62,116.65
1925	16,039.63	Dec. 31, 1925	87,196.60
1926	20,185.83	Dec. 31, 1926	114,451.27
First eight months of 1927	15,175.45	As of Aug. 31, 1927	117,702.62

During the present year $20,000.00 have been invested in high grade securities by recommendation of the Finance Committee and by authority of the Board of Directors. There has been purchased $5,000.00 par value each of New York Telephone Company 6 per cent bonds, Missouri Pacific First and Refunding 5 per cent bonds, Swift & Company 5 per cent bonds, and Columbia Gas & Electric Company 5 per cent debentures.

By the end of this year the assets of the Society should be near $140,000.00. There has not been a single complaint from our membership that we are accumulating too large a surplus. Reducing the excess of income over expense can be accomplished easily by executive decision. To maintain our present average excess of income over expense requires that people be willing to pay more for our service than the service costs. This cannot always be done by executive decision. Since we are fortunate enough to be rendering such valued service at present it seems wise to allow our surplus to accumulate. An organization, as well as an individual, should not spend money without endeavoring to obtain equivalent value. The Board of Directors follows this policy in authorizing expenditures, a policy which, if continued, will insure the permanent success of our Society. Although we have a healthy surplus, the income from our capital is an insignificant part of the total. In 1926, for example, our total income was $242,669.71, of which only $4,265.19 was interest on our assets. There is no cause for alarm, therefore, at the amount of our assets, or at the rate of growth of our surplus.

Inasmuch as this is the last annual report of your present Treasurer, he wishes the members to know that Mr. Carl Ohlson, working harmoniously with our able Secretary, handles the real work of the Treasurer's office. Also the former Treasurers, Messrs. W. S. Bidle and J. V. Emmons, did their work so well that there has been little for the present Treasurer to do but to carry on with their plans. Finally, the splendid spirit of our Secretary, our President, past Presidents and Board of Directors, has made the Treasurer's duties a real pleasure rather than a burden.

Following the presentation of the reports of the president, secretary and treasurer, S. M. Havens, chairman of the Constitution and By Laws Committee, submitted the following proposed changes and amendments to the constitution of the society which were adopted by the meeting and thus became immediately effective. These changes were prepared by the committee in compliance with the new General Corporation Act of Ohio passed by the last legislature and effective June 9, 1927. The proposed changes to the existing constitution of the Society were prepared in printed form and sent to all members of the Society in June, 1927. The amendments and changes are as follows:

Amendments 1 to 5 were submitted for the purpose of discontinuing the "Associate" classification of membership.

AMENDMENT No. 1

Amend Article IV to read:

ARTICLE IV

MEMBERSHIP

Section 1. The membership of the Society shall consist of

(a) Founder Members
(b) Honorary Members
(c) Members
(d) Sustaining Members
(e) Juniors

who shall be defined and possess the qualifications shown in Section 2 hereof.

Section 2.

(a) A Founder Member shall be such a person as the Board of Directors shall determine has been instrumental in the founding of the Society *or has rendered distinguished service to the Society.**

(b) An Honorary Member shall be a person of acknowledged exceptional eminence. The total number of Honorary Members shall not at any one time exceed twenty-five.

(c) A Member shall be a person, twenty-one years of age or over, who is engaged in work related to the manufacture or treatment of metals, or the arts connected therewith.

(d) Sustaining Members shall be those persons, firms or corporations, who, because of exceptional interest in the work of the Society, contribute the annual dues of Sustaining Members as hereinafter set forth.

(e) A Junior shall be a person interested in, or engaged in work related to, the manufacture or treatment of metals or the arts connected therewith, and who is either (1) under twenty-one years of age, or (2) whose *principal* occupation is attendance as a student at some institution of learning.

Section 3.

All persons who, under the previous Constitution, are Associates in good standing, at the time the amendments to this Article take effect, shall automatically become Members of the Society. All dues paid by such Associates covering a period subsequent to the effective date of such amendments, shall be applied pro tanto on their dues as Members.

AMENDMENT No. 2

Article V, Section 2.
Strike out (a).
Strike out paragraph marked (b).

AMENDMENT No. 3

Article VI, Section 1, Subdivision (d).
Strike out the word "associates".

AMENDMENT No. 4

Article VII, Section 1.
Strike out the word "associate".

AMENDMENT No. 5

Article VIII, Section 1.
Strike out the words "For Associate ....$15.00"

The purpose of amendment No. 6 is to correct an evident misspelling in the previous constitution.

AMENDMENT No. 6.

Article IX, Section 4.
Change the word "by-law" to "by law".

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*Words, sentences or paragraphs in italics indicate those portions which have been added to the previously existing constitution.

The purpose of amendment No. 7 is to reduce the term of office of the Vice-President from two years to one year.

AMENDMENT No. 7

Article XI, Section 2.

Amend to read as follows:

Section 2. The term of office of each of the officers above mentioned shall begin on January 1st next suceeding their election. The term of office of the President shall be for one year and at the completion of such term he shall become a Director for a further period of one year. *The term of office of the Vice-President shall be for one year.* The term of office of the remaining officers and directors specified shall be for two years each.

At the first election of officers in December, 1927, under this amended constitution, and in each alternate year thereafter, there shall be elected, as provided herein, a President, a Vice-President, a Treasurer, and two Directors; and at the next succeeding election, and in each alternate year thereafter, there shall likewise be elected a President, a Vice-President, a Secretary and two Directors.

Amendment No. 8 is made to correct an obvious error in the previous constitution.

AMENDMENT No. 8

Article XI, Section 4, Subdivision (c).

Strike out the word "preceding" and insert the word "succeeding".

The purpose of amendment No. 9 is to render unnecessary the sending out of letter ballots where there are no nominations other than those presented by the regular nominating committee. This saves time and considerable money.

AMENDMENT No. 9

Article XI, Section 4.

After subdivision (c) insert a new subdivision as follows:

(d) *If no other candidates for officers or directors be nominated as provided in subdivision (c), then the National Secretary shall notify the tellers, who shall certify the election of the candidates nominated pursuant to Section 4 (a) of this Article, for the terms of office for which they were nominated.*

The purpose of amendment No. 10 is to reletter the subdivision and provide for a contingency wherein December 20th may fall on a Sunday or holiday.

AMENDMENT No. 10

Article XI, Section 4, Subdivision (d).

Amend to read as follows:

(e) If candidates are nominated as provided in Section 4 (c) of this Article, then, on or before December 1st next succeeding, the Secretary shall mail to each member entitled to vote for officers and directors a ballot in such form as the Board of Directors shall determine, stating the names of the candidates for the various offices to be voted upon, as nominated by the regular nominating committee, together with any special nominations regularly made. Such ballots shall also provide a space in which the person voting may write the name of any member for whom he desires to vote. Each voter shall suitably mark or otherwise write on his ballot so as clearly to indicate his choice for the various offices, and shall return his ballot in a sealed envelope to the office of the National Secretary. Such envelope shall be marked on the outside "Ballot for Officers" and shall be contained in another envelope on which shall be provided a space for the signature of the voter. Voting for officers shall close at 10:00 o'clock in the forenoon of December 20th of each year, *unless that date shall fall on a Sunday or a day which is a legal holiday in the state of Ohio. In either of the latter events voting shall close at 10:00 o'clock in the forenoon of the next suc-*

ceeding day which is not a Sunday or holiday. The sealed letter ballot shall be opened by the Tellers of Election only, and shall be canvassed by them, and the result shall be certified by such tellers in writing immediately upon completion of the count. Such certification shall be forthwith filed with the National Secretary. In the absence of fraud or mistake, the officers certified by the tellers to have received a plurality of the votes cast shall be the duly elected officers of the Society and their term of office shall begin the first day of January next succeeding their election.

The purpose of amendment No. 11 is to eliminate something that is a mere statement of fact and properly does not belong in the constitution for that reason. It was copied from the previous constitution.

AMENDMENT No. 11

Article XI, Section 5, Subdivision (c). Strike out the paragraph marked (c).

The purpose of amendment No. 12 is to obviate the necessity of calling a special meeting of the members as provided by Section 115 of the General Corporation Act of Ohio, if it should ever become necessary to dispose of real estate.

AMENDMENT No. 12

Article XI, Section 8.

Add to the Article a new section as follows:

Section 8. The Board of Directors may, by the affirmative vote of not less than two-thirds of its membership, given at a meeting of such Board duly called and held, sell, lease, mortgage, or otherwise dispose of any real estate now or hereafter owned by the Society. Notice of such meeting shall clearly state that the disposal of such real estate will be considered at such meeting.

The purpose of amendment No. 13 is to combine Sections 1 and 2 of Article XV and to make possible greater continuity in the membership of the standing committees.

AMENDMENT No. 13

Article XV, Section 1.

Amend to read as follows:

Section 1. The following standing committees shall each consist, unless otherwise in this Article provided, of not less than three qualified members. They shall be appointed by the President, by and with the consent of the Board of Directors, and vacancies shall be filled in the same manner. The terms of office of the members of the committees shall be fixed in like manner except that the term of no member of a standing committee shall exceed *three* years or until his successor shall be appointed. The necessary number of members shall be appointed to the standing committees during the month of January of each year. The President and Secretary of the National Society shall be ex-officio members of all standing committees. The duties of the standing committees are set forth below:

The purpose of amendment No. 14 is to combine the work of the Meetings and Papers Committee with the Publications Committee, which as a matter of practice is actually being done now.

AMENDMENT No. 14

Article XV, Section 1, Subdivisions (b) and (c).

Strike out subdivisions (b) and (c) and insert in their place the following:

(b) Publications Committee.—This Committee shall receive all papers which are to be presented at any meeting of the National Society, and shall recommend what

papers and discussions, or parts of same, shall be printed in the Transactions or otherwise given publicity. This Committee shall have the supervision of the publication of the Transactions of the Society. It shall be the duty of this Committee to secure the presentation of papers and addresses before all sessions of the Society and to aid the local chapters in securing papers and addresses. The Editor of the Transactions, if one be employed by the National Board, shall be ex-officio member of the Publications Committee.

The purpose of amendment No. 15 is to eliminate the National Membership Committee, whose functions are largely taken over by the local chapters.

AMENDMENT No. 15

Article XV, Section 1, (d).
Membership Committee. Strike out the entire subdivision.

The purpose of amendment No. 16 is to eliminate the Library Committee, the duties of which are largely taken care of by the National Office.

AMENDMENT No. 16

Article XV, Section 1, Subdivision (e).
Library Committee. Strike out entire subdivision.

The purpose of amendment No. 17 is to eliminate the Research Committee for the reason that no funds have been appropriated to carry on research and it is not the policy of the Society at present to undertake such research work.

AMENDMENT No. 17

Article XV, Section 1, (f).
Research Committee. Strike out entire subdivision.

AMENDMENT No. 18

Article XV, Section 1, Subdivision (g).
Change (g) to (c).

AMENDMENT No. 19

Article XV, Section 1, Subdivision (h).
Change (h) to (d).

Amendment No. 20 is suggested because statements contained in this eliminated paragraph are combined in Section 1 of this Article supra.

AMENDMENT No. 20

Article XV, Section 1.
Strike out last paragraph of Article which reads as follows:

"Appointment of Standing Committee. The necessary number of members shall be appointed to the standing committees during the month of January of each year. Term of office of the standing committees shall be for not exceeding two years or until their successors are appointed."

The purpose of amendment No. 21 to Article XVIII is to take advantage of the revised statutes of Ohio, effective June 9, 1927, and is in accord with the recommendations of our counsel, Wm. J. Dawley, Esquire, of Cleveland.

AMENDMENT No. 21

Article XVIII, Sections 2 and 3.
Amend to read as follows:

Section 2. Any amendment duly proposed as provided in Section 1 of this Article may be adopted in the following manner: At least sixty days before an annual or

special meeting of the members of the Society the National Secretary shall give written notice by mail to each member entitled to vote, setting forth the proposed amendments to the Constitution. The amendments may be adopted with or wihout further changes by a majority vote of members present at such annual or special meeting duly called and held, provided a quorum is present.

Section 3. Amendments to this Constitution may also be adopted in the manner hereinafter described in this section, provided it is so ordered by the Board of Directors. When amendments to the Constitution have been duly proposed, then the National Secretary shall mail to each member entitled to vote a printed ballot upon which shall appear a full and complete statement of the proposed amendment. With such ballots shall be sent a notice that voting thereon by mail shall close at the office of the National Secretary at 10:00 o'clock in the forenoon of a day not less than sixty days subsequent to the date of mailing of the notice. An affirmative majority of the votes on the ballots so received by the National Secretary shall be sufficient for the adoption of any amendment. The tellers shall, on the date and time fixed by the notice, count the ballots as provided in this Constitution and shall certify in writing the adoption or rejection of the proposed amendments or any of them. No member's vote shall be counted unless received at the National Office within the time fixed by the notice provided for in this Section.

Following this order of business, Howard Stagg, Chairman of the National Nominating Committee for the year 1927, presented the report of committee as to its selection of the men qualified to be officers of the society for the ensuing year. This report is given on page 529 of this issue of TRANSACTIONS.

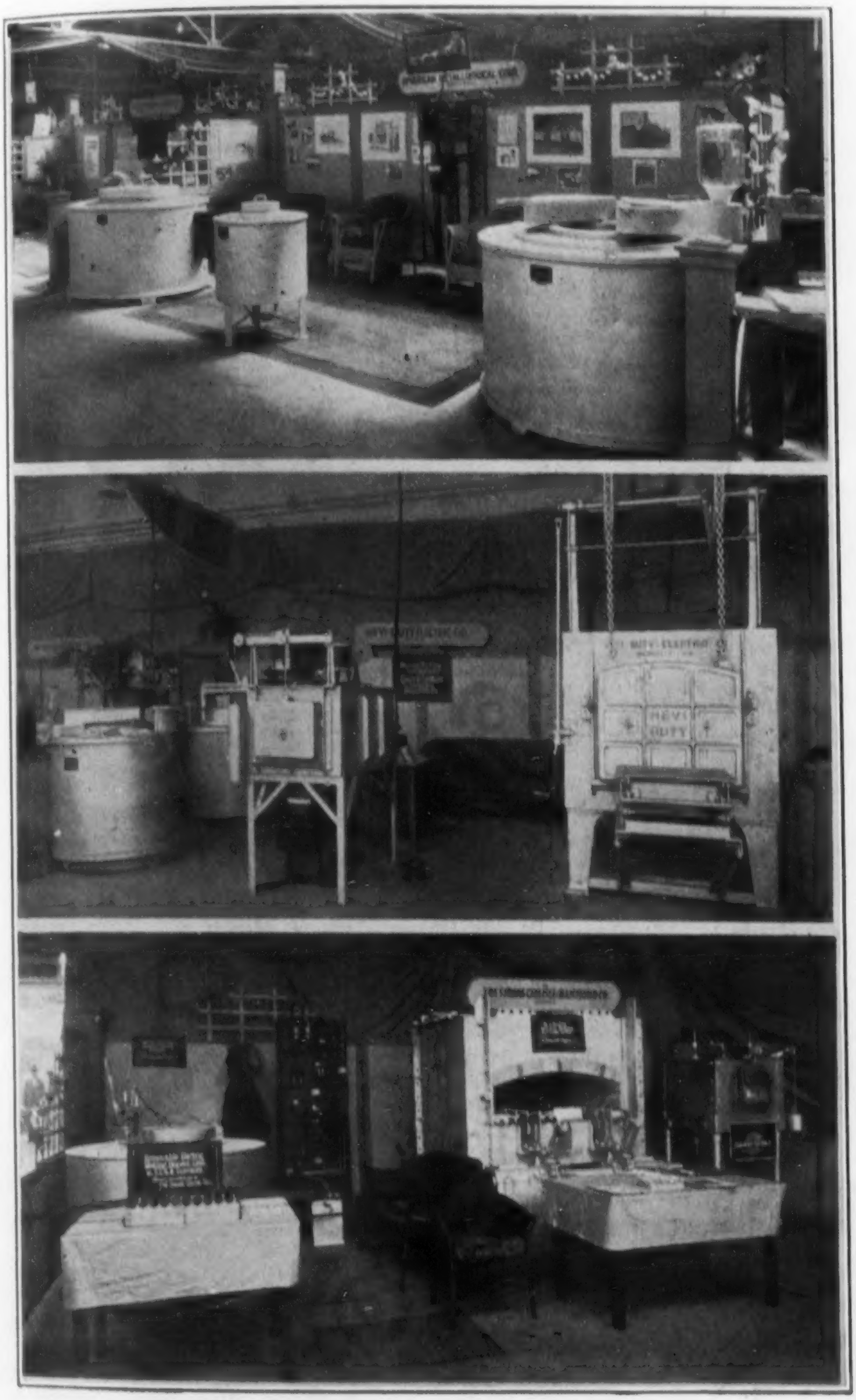
Upon the completion of this order of business, the Annual Meeting of the Society was adjourned.

Immediately following the adjournment of the Annual Meeting, Chairman J. Fletcher Harper introduced Professor Alfred H. White, head of the Chemical Engineering Department of the University of Michigan, who presided during the E. D. Campbell Memorial Lecture. Following a brief introduction, Professor White presented Dr. Zay Jeffries, who gave the second Campbell Memorial Lecture, entitled "A Contribution to the Theory of Hardening and the Constitution of Steel."

The afternoon technical session was held in the Book-Cadillac Hotel and was a joint meeting with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, which division had prepared the program for this session. W. R. Webster presided as Chairman. Five papers were read by their respective authors in the following order:

2:00—4:00 P. M.—*Commercial Forms and Applications of Aluminum and Aluminum Alloys*—P. V. Faragher.
Machining Aluminum—R. L. Templin.
Physical Characteristics of Commercial Copper-Zinc Alloys—W. H. Bassett and C. H. Davis.
Nickel and Monel Metal—C. A. Crawford.
Wrought Zinc—C. S. Trewin.

VIEWS OF THE EXPOSITION



VIEWS OF THE EXPOSITION

DR. ZAY JEFFRIES
Edward De Mille Campbell Lecturer for 1927

These papers were highly interesting and much credit is due the Institute and its members in the preparation and presentation of these most valuable contributions.

THURSDAY, SEPTEMBER 22

The Thursday morning technical session was called to order at 10:00 A. M. by Chairman Frank P. Gilligan, assisted by Miss Frances Hurd Clark, as Vice-Chairman. This session consisted of five papers as follows:

10:00—10:30 A. M.—*On the Significance of the Proportional Limit of Steel at Elevated Temperatures*—F. B. Foley, The Midvale Company, Nicetown, Philadelphia.

10:30—11:00 A. M.—*Recent Experiments Relating to the Wear of Plug Gages*—H. J. French and H. K. Herschman, Bureau of Standards, Washington, D. C.

11:00—11:30 A. M.—*What Happens When High Speed Steel is Quenched*—B. H. DeLong and F. R. Palmer, The Carpenter Steel Company, Reading, Pa.

11:30—12:00 A. M.—*On the Double Carbide of High Speed Steel*—Dr. Arne Westgren and Gosta Phragmen, Metallografiska Instituent, Stockholm, Sweden.

On a New Method of Quenching Steel in a High Temperature Bath—Dr. Kotaro Honda and Kanzi Tamaru, Imperial University, Sendai, Japan. (By title)

The first three papers were presented by their respective authors, while the fourth one was read by Dr. Zay Jeffries and the fifth one was read by title only. Much valuable and interesting discussion, both written and oral, followed the presentation of the papers, and all of this discussion will appear in TRANSACTIONS at a later date.

The afternoon technical session was called to order at 2:00 P. M. by Chairman H. J. French, who was assisted by F. B. Foley as Vice-Chairman. The six papers scheduled for presentation are as follows:

2:00—2:30 P. M.—*Dilatometric Analysis of Steel and Some Results of Dilatometric Heat-Treatment*—R. W. Woodward and Stanley P. Rockwell, The S. P. Rockwell Company, Hartford, Conn.

2:30—3:00 P. M.—*The Physical Properties of Several Chromium-Aluminum and Chromium-Nickel-Aluminum Steels*—V. O. Homerberg and I. N. Zavarine, Massachusetts Institute of Technology, Cambridge, Mass.

3:00—3:30 P. M.—*The Economic Value of Nickel and Chromium in Gray Iron Castings*—D. M. Houston, The International Nickel Company, New York City.

3:30—4:00 P. M.—*Expansion Characteristics of Low Expansion Nickel Steels*—Howard Scott, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

On the Determination of the Heterogeneous Field In the Iron-Nickel System—Dr. Kotaro Honda and Sansaku Muira, Imperial University, Sendai, Japan (By title)

Heat Treatment of Two Ball Bearing Steels—Bengt Kjerrman, S. K. F. Gothenberg, Sweden. (By title)

The first four papers were presented by their respective authors, while the last two were read by title.

ANNUAL BANQUET

The annual banquet of the American Society for Steel Treating was held Thursday evening, September 22, in the Ball Room of the Hotel Statler. This banquet was exceedingly well attended,

VIEWS OF THE EXPOSITION

MISS FRANCES H. CLARK and MISS LILLIAN ELAM

Miss Clark presided as vice chairman of the Thursday morning technical session of the A. S. S. T.

Miss Elam is an English scientific investigator, who traveled from England to attend the convention and enter the technical discussions.

there being about 500 members and guests present. The following officers, members and guests were seated at the speakers table: J. M. Watson, R. G. Guthrie, F. P. Gilligan, John A. Mathews, Wesley P. Sykes, F. G. Hughes, Charles F. Kettering, J. F. Harper, Edgar A. Guest, W. R. Whitney, Zay Jeffries, J. H. Hunt, W. H. Eisenman, R. M. Bird, S. W. Utley, W. S. Bidle, Hyman Bornstein, L. D. Hawkridge and Robert Atkinson. The master of ceremonies was Edgar A. Guest, who cleverly introduced each of the speakers of the evening and interspersed these introductions with humorous verses and stories.

In order that those members of the society who did not have the good fortune of attending the annual banquet might be informed of what took place we are printing in full the remarks, presentations and speeches.

The Banquet Session, Thursday night, was called to order at

8:55 P. M. by J. M. Watson, who introduced the master of ceremonies, Mr. Edgar A. Guest.

EDGAR A. GUEST: Mr. Watson, ladies and gentlemen of the American Society for Steel Treating, I never was a toastmaster in my life; I have always wanted the chance. I have an idea as to how this sort of a job should be done, but I didn't know that I was to do it until a day or two ago, and then I said, "Well, I don't know a thing about steel treating, I don't know the people, don't know the words, can't pronounce them or spell them, but I am going over there to show those people what I think a master of ceremonies ought to be."

Mr. Kettering came in and said, "My goodness, Eddie, what are you doing?" Well, I don't know, but it reminds me of the story that President Taft used to tell of an Irishman in Tipperary who got into a fight with another Irishman and in the midst of the argument this Irishman grabbed his shillalah, tapped the other Irishman on the skull, and he fell dead. They held a post-mortem examination on the victim and discovered that the dead man had what is known in medical science as a paper skull.

Mike was tried and convicted of manslaughter, but before passing sentence the judge asked the customary question whether he had anything to say for himself.

"Yeh," said Mike, "I have. I hit him all right, and he died; ye've convicted me and I suppose I'll have to take me medicine. But I'd like to know, Your Honor, what the divil a man with a skull like that had doin' in Tipperary."

What I would like to know is what the divil a man with a skull like mine has doin' in an organization of pure science. Now, there are a pair of pure scientists going to work at 10:00 o'clock tonight in Chicago, and we are going to tune in on that radio at 10:00 and get that exhibition of science.

This noon, wondering what I could do for you, appreciating the debt I owe to you for what you have done for me, because if it wasn't for the scientists, I would be naked and hungry now:

"While ordinary mortals play
  And laugh and dance the hours away,
The men of science, hid from sight,
  Toil at their problems through the night,
Within the laboratory room,
  Seeking to bring the thought to bloom.

"We laugh and jest and eat and sleep,
  The paths we tread are rutted deep,
The little tasks we have to face
  Are known to all, and commonplace;
But men of science fare alone
  Into the future's great unknown.

"From ceaseless toil at last there springs,
  One of the world's astounding things,
Proved beyond doubt and fit for fools
  To place within their kits of tools;
And this becomes our common text:
  'What will mankind discover next?'

"We are the waiters of the world,
  Debtor to every test tube curled,
The frail dependents on the few
  Who bring to birth the glorious new;
Ours is to wonder while we live,
  What next the scientists will give."

You know, I am just one of the boys who works in a newspaper office, the kind of a newspaper man, Mr. Kettering, you know, who came out of the office one day with a terrific grouch, and as he was crossing the street, a little newsy on the street corner hollered, "Paper, Mister? Paper, Mister? Paper, Mister?"

No," says this bird, "we make those things."

"Gee!" said the kid, "that's the reason we can't sell 'em."

I never look at this man Kettering without envying him. I wish I could leave behind me just a tiny one of the many things he is going to leave behind him. It has occurred to me that when the game is over, ladies and gentlemen, when there is to be no more tomorrow for me, when I have seen the last thing I shall see and done the last thing I shall do and I get over across the Stream, there may be some inquisitive one at the gate who will stop me and say, "What's your name?"

"Edgar Guest."

"Wait a minute!" and he'll look up in the files, "Oh, yes, yeh! You had so many years and so many months and so many weeks and a couple of days extra. Anybody down there any better off because we let you live that long? Or did you spend all that time on yourself?"

Now, if he should get that inquisitive and should go so closely into the swindle sheet, I hope I could look him in the eyes and say, "Listen, Mister, I never thought of it just that way, but since you have put it up to me, yes, I had all that time, I spent it all, I had a good time spending it, too. I spent a lot of it on me, but I don't think I spent it all on myself. I think once in a while I did try to do a little bit for somebody else. Now, I don't want to brag; send somebody over the road and ask."

"I'd like to think when life is done,
  That I had filled some needed post,
That here and there I'd paid my fare
  With something more than idle boast;
That I had taken gifts divine,
  The breath of life and manhood fine,
And tried to use them now and then,
  In service for my fellow men.

"I'd hate to think when life is through,
  That I had lived my round of years,
A useless kind that leaves behind
  No record in this vale of tears;
That I had wasted all my days,
  By treading only selfish ways,
And that this world would be the same,
  If it had never heard my name.

"I'd like to think when life is done,
That here and there there shall remain
Some happier spot which might have not
Existed, had I toiled for gain;
That I had paid with something fine
My debt to God for life divine."

Now, that is all I am going to do in the way of any sort of an introduction except to tell you that I am happy to be here with you and delighted to have you come to my city, which I love more than any other city in the world, and I was delighted to hear at my home this evening from a member of the Society who would much rather stay at my house and listen to the prize fight over the radio and eat food at my table while I came down here. He said, "I'll swap with you; you go to the banquet and I'll stay here." The thing that pleased me was that he said this was the greatest convention the Steel Treaters have ever had.

It becomes now my duty to present to you your beloved President, Mr. Harper.

J. FLETCHER HARPER: Mr. Guest, ladies, honored guests and fellow members:

Five years ago the American Society for Steel Treating met in Detroit, and this week we are again honored to be your guests. It seems fitting that this Society should meet in the Motor City, which has done so much for the advancement in the treatment of metals. Our Society has progressed rapidly since our last visit here. However, it is but a reflection of the progress of industry. The automotive industry has long been in the lead, and it is an inspiration to again be in the center of such activities.

We appreciate this opportunity that you have afforded us to visit your industries and be your guests. There are meeting this week three other technical societies, the American Welding Society, the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, and the production Meeting of the Society of Automotive Engineers. We bid them welcome to all of our activities and we sincerely hope that the cordial relationships which now hold shall long exist.

Last year your then President, Robert M. Bird, presented a bell, the bell which you see before you, which was to be presented to the chapter of our organization which had been, in the judgment of the President, and the President alone, of the most value to the National organization. At the end of this meeting I wish to place this bell in charge of the San Francisco delegation to be turned over to the Golden Gate Chapter.

"And now I would like to say unto our bard,
That steel men are not really hard;
Their work has rhythm all along the line,
Although its expression may not rhyme;
But words of wisdom, sugar coated with jest,
Are always welcome from Edgar Guest."

To our many members and guests who are here this evenng, I sincerely hope that your stay has been educational, and to our exhibitors,

I hope financially successful, and, best of all, I hope that new friendships and new associations have been formed which will prove of mutual benefit to all.

EDGAR A. GUEST: If the convention continues over tomorrow and you will meet me in the convention hall at 11:00 o'clock in the morning, I will give a demonstration of heat treating steel. (Laughter)

I met the Reverend Merton Rice one night in the Michigan Central Depot as he was leaving for Cincinnati and I was leaving for Chicago, and he said, "Wait a minute, Eddie, wait a minute,—I have one for you. I picked it up in a little Kansas paper last week when I was out there, while I was riding through the plains, and it gave me a laugh and I clipped it out and brought it back to Detroit to give it to you, because I thought it would give you a laugh."

He fumbled about in the little black notebook that all ministers seem to carry in their upper right-hand vest pocket and finally found the clipping and handed it to me, and I read these lines:

"He drank the nectar from her lips,
As under the moon they sat,
Then said, 'I wonder if anyone else
Ever drank from a mug like that!' "

And I laughed and the Methodist minister laughed, and, ladies and gentlemen, there wasn't the slightest excuse in the world for my introducing that into this program tonight except that it happened to come into my head and possibly to show you what kind of literature some Methodist ministers carry around with them.

I have been secretly informed that there are to be a number of presentations. All my life I have sat either on the right hand or the left hand of the gentleman who gets the gold watch. I have been treasuring the hope that some day the lightning might strike my chair, but it never has. I now take a great deal of pleasure in presenting to you William S. Bidle, who comes gift bearing, I believe.

WILLIAM S. BIDLE: Mr. Chairman, ladies and gentlemen:

There are a great many nice things I would like to say about Bob Bird, but, unfortunately, the main event—the prize fight is coming very soon, so I will have to make my remarks very, very short.

As you know, there is a Past-President's Medal awarded at each annual convention. Probably the language that best expresses what I want to say is that which is engraved on the back of this medal which is to be given to Bob Bird: "Awarded to Robert M. Bird in appreciation of his excellent service as President in 1926."

Perhaps some of you know that Bob Bird visited every chapter in the Society, practically from Maine to California. It happened to be my privilege to be one of the workers under Bob, and if I were to use any one particular word, I would say "Faithful Bob."

However, in presenting this medal I am going to be perfectly frank to admit that I think quite a large injustice has been done and that this medal should be plural and not singular, Mrs. Bird accompanied Bob on

most of these trips and did a wonderful work in the background. Now, of course, a handsome young man going around the United States—well, I don't know as I blame her an awful lot.

However, be that as it may, Bob, here is your medal, and the only thing I would say is that in future years, as you are showing that to the children and to all the other people, use that word which has lately come into considerable popularity, "We."

R. M. BIRD: Mr. Toastmaster, this is not the gold watch. Dear old

WESLEY P. SYKES
Howe Medalist for 1927

Bill Bidle, ladies and gentlemen: It is horrible to grow old and it is so hard to grow old gracefully. It is mortifying to be laid on the shelf and still more mortifying to have the news of that shelf-laying process broadcast in this manner. If this were a personal matter, I would hang my head in shame and take my affliction in solitude, but it is not such but is the only time in the year when the American Society for Steel Treating, through this presentation, expresses its thanks to all those who during the past year have worked so faithfully for her, and it really is the initiation into the Royal Brotherhood of A. S. S. T. Has-Beeners for all of us, into which in this novitiate class comes old Bob Guthrie and old Hy. Bornstein and all the good old souls whose names are now to be taken off the list of general national committees, and the chairmen and officers of the chapters. I wish that similar tokens could go to every one of them. We are all human, we may laugh at it, we may jeer, but as a matter of fact, as the days go by, there are many times when we will talk about

these things to our children and perhaps our children's children, and often in looking at this tangible token, there will be unlocked memories which otherwise might stay in those little cells of ours.

So I am going to speak just for a minute for this Royal Order of Has-Beeners, that glorious company. You see, it takes away the sting of this mortification, it makes me bear up with fortitude to talk for them, to these young colts, we old work horses. You young colts, full of vim and energy, just champing at the bit and getting into harness, go to it, go to it, and, above all things, don't let anybody, particularly any one of us old timers, stamp down on your enthusiasm; go to it and make A. S. S. T. bigger and better than ever before and make us happy, and if some of us are not too decrepit to help pull the cart for a day or two, make the rest of us happy by calling on us. There is only one thing which we will not grant you. We dare you, we challenge you, in any day, in any age, to show that you have given more of yourselves in this work, in loyalty, yes, and in love for A. S. S. T., than we in our generation.

Thank you.

EDGAR A. GUEST: I am for Mr. Bird heart and soul. I believe absolutely, ladies and gentlemen, in the permanent recognition of service rendered. I have tried cashing the rising vote of thanks at the bank and the grocery store, I have tried pinning them in my shirt front, and they are no good, absolutely no good. You can't show them to the children and you can't take them home to the Mrs.

There is still more presentations to come. Past President Frank P. Gilligan has a very happy service to render. I understand he is to present to you a struggling young author, a writer who has already won his spurs, a writer whom I envy because he has used a word which I couldn't spell or pronounce. He will present to you Mr. W. P. Sykes, whose technical paper on,—whose technical paper on,—there was a time, there was a time, ladies and gentlemen, when a young Irishman died at the age of 28 and the family asked to do it up in first-class style, so they went to the only man in the town who could engrave silver and, unfortunately, the only figure that he couldn't make was an "8." They wanted this boy's name and his age, 28, on the plate, and he agreed to do it, but when he found the boy was 28, he didn't know how to get around that thing, but he finally figured out a way to do it by putting four 7's on the thing.

They brought in the lowly orator, who never had met the boy, and asked him to deliver the funeral sermon, and he did it in about this way. He said, "Dear friends, we are assembled here on this very sad and solemn occasion, and it is always a pitiful time when death enters the home. It is particularly sad, it is exquisitely sad, when a young man is cut off at the early age of, — — — As I was saying, death is always a sad thing, but it is particularly sad when a young man is taken away from his friends and folks at the early age of, — — — As I was saying, when a young man is cut off at the early age of, — — — How the divil did this fellow escape the Flood?" (Laughter).

Mr. Gilligan will present to you Mr. W. P. Sykes, whose technical

paper on The Iron-Molybdenum System won for him fame and renown.

F. P. GILLIGAN: Mr. Toastmaster, ladies and gentlemen:

Until quite recently it has been generally understood that definite amounts of carbon had to be added to iron or to iron-base alloys in order to provide suitable physical properties to meet the needs of industrial requirements. As a result of certain labors during the past year by one of our younger members, it has been ascertained that it is now possible to produce a very useful iron-base alloy without the addition of any carbon. The labors of that young man were presented in TRANSACTIONS during the past year under the title, "The Iron-Molybdenum System." His labors have been deemed worthy of the Henry Marion Howe Medal Award. Mr. President, I present Mr. Wesley P. Sykes.

PRESIDENT HARPER: Mr. Sykes, on behalf of the Board of Directors and the officers and members of the American Society for Steel Treating, it gives me great pleasure to present to you the Henry Marion Howe Medal. I sincerely hope that it may be an inspiration to further researches and further honors.

EDGAR A. GUEST: Two servant girls were carrying on a very interesting conversation one day, discussing various foods and things, and one asked the other if she had ever eaten any terrapin. She said, "No, but I've been where it was."

Henceforth and from now on, if anyone asks me if I know anything about molybdenum, I'll say, "No, but I've been where it was."

I understand your next Santa Claus is a golf player. That is the information which was furnished to me. I like to get my information about golf players on the course. Years of experience have taught me that you can't trust advance-first-tee information.

I think it was Dr. Jeffries who was playing with the Scotch caddie and came to a one-shot hole and the Doctor looked it over and said, "It looks like a cleek shot to me." And the Scotch caddie said, "You'll do better with your spoon, sir." The Doctor looked the situation over and said, "It looks like a cleek shot."

"You'll do better with your spoon, sir," said the Scotch caddie.

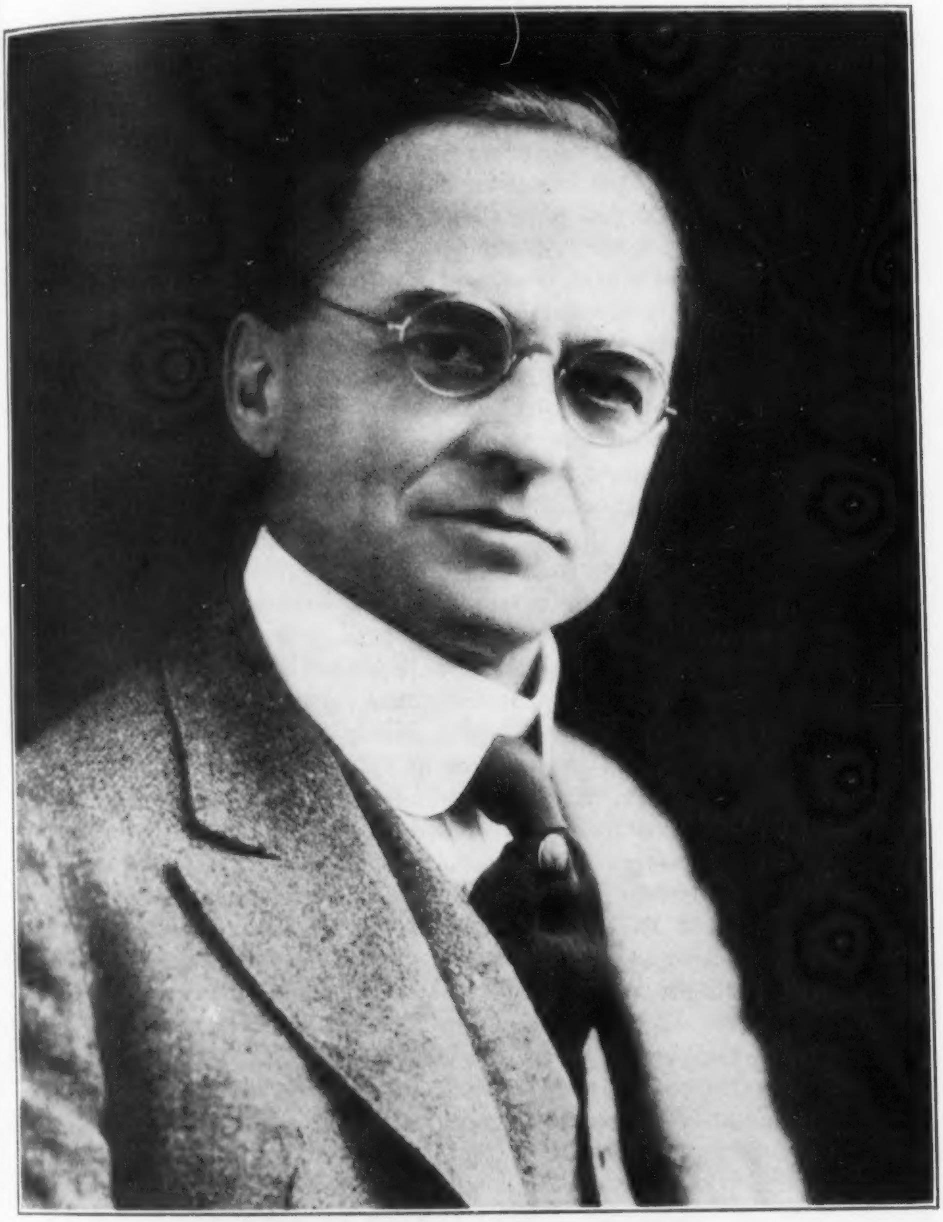
Whereupon, the Doctor took his cleek and laid the ball about six inches from the cup. When they approached the green, he turned to the caddie and said, "I told you it was a cleek shot."

"You would a-done better with your spoon," said the Scotch caddie.

I take a great deal of pleasure in presenting to you Dr. Jeffries.

DR. ZAY JEFFRIES: Mr. Toastmaster, ladies and gentlemen:

I think the historians of the future will probably look back on us as we have on some of the generations before us, as very smart animals who learned how to use the resources that had been stored up for long ages past, mineral resources which had been concentrated in the earth, coal, petroleum, lumber, etc. But at a little later date, perhaps, they will find that these same people were intelligent enough to try to conserve those resources, and that is the process that we are in now to such an extent that in the last thirteen years the income of the people of the



WILLIS R. WHITNEY

United States buys 25 per cent more general commodities than it did thirteen years ago. That is indeed a very rapid appropriation of the resources of the earth and, of course, there must be a reason for that.

As an example, it would cost the people of the United States two billion nine hundred million dollars more per year than it does if it maintained the same level of illumination that it does, using the old carbon lamps. Furthermore, it would take over one hundred thousand candles

to supply the light which is supplied from one small 500 watt Mazda Lamp.

The developments of research during our age and the industrial applications and the benefit of all humanity, the benefit all humanity has received from this research, is well known to us all. We all know also of the great contributions that have come from the various research laboratories, and particularly from one research laboratory, that of the General Electric Company, which has been running now for more than a quarter of a century. Only a few high spots, the development of ductile tungsten and wrought tungsten, which is the basis for our present incandescent lamps, the X-ray equipment which is so useful in the study of metals, the crystal analysis of metals, the information that came with that, and lastly, the new developments in radio, where these tungsten filaments are used to emit electrons to help magnify these small signals that are received through the ether.

But I am not going to stress the point of specific development in the field of research. I would like to stress the point, just very briefly, of the great good to the whole world of industrial research as a whole. And we look upon Dr. Whitney, Director of Research of the General Electric Company, as a leader in that field and one who has done much to cause industrial research to spread throughout this country, one who has done much to prove that industrial research pays, not only that it pays the company supporting the research but it pays civilization as a whole.

Furthermore, he has been a leader and a pioneer in the whole matter of the education of the public, and particularly the publication of the findings of research workers in the laboratory. It is very probable that if it had not been for Dr. Whitney's pioneer work in this field, we would not be meeting in this room this evening. We depend on the publication of the results of research for the maintenance of a Society like the American Society for Steel Treating, and the splendid papers that we have had here this week have contributed to the success of this meeting and have been responsible, in a general way, for our presence here and for this meeting tonight. So I take pleasure in presenting Dr. Willis R. Whitney, Director of Research of the General Electric Company, to our President, Mr. Harper, to have Honorary Membership conferred upon him.

President Harper: Dr. Whitney, it gives me great pleasure, on behalf of our organization, to present you with this certificate of Honorary Membership.

Dr. Whitney: Mr. Guest and Mrs. Guest,—You ought to be very much pleased with Mr. Guest, Mr. Harper and Dr. Jeffries.

I have a great deal that I would like to say. I am going to try to make it brief. I believe that this is the best of all possible worlds, but that it is going to be improved a lot, and continuously, and almost daily, and that you men are doing it and are going to continue doing it.

There hasn't been enough serious matter brought to your attention tonight. This is a scientific organization. There has been only a little bit said about the value of publication and the value of advertising and what research really is, and I have to put it in its proper place. I say

radical experiments have got to be tried more, just such experiments as you are trying now in giving me this honor, it is a radical experiment. Try anything once, and you haven't got to try it again. I don't believe there is any plan for repeating exactly this experiment. Even fools rush in where angels fear to tread, and that is possibly why I am here.

But just think of this fact. There are a whole lot of holes apparently, that the angels have kept out of. Maybe all the minds in the world are in a kind of a hole. Somebody has to dig into those unknown things, the things that scare the angels, and you fellows and I have to do it. Call us fools if you will. Now, just between us, as man to man, let me say, what did the angels do for you in the flying business? What did the angels show you about flying? Now, I don't know anything about flying; I was taken up by Mr. Kettering once in an airplane, and he didn't do the fatal Atlantic dip or the tail spin, but when I got out, I didn't know anything about flying except that the air was awfully rough. No, I don't know anything about flying, flying machines or aeronautics, but I can talk readily about things I don't know, and I maintain that the angels didn't tell us much about flying.

Now, why didn't they? Well, I look at the angels, if you will permit me to say so, as being American women, blondes, usually, with wings, and they have flown forever. But they never have tried an experiment. They never have had any trouble, so far as I know, and you can't learn from that kind of a person and you can't learn by doing that kind of flying. Let me point out right here that from all our present knowledge, the angels have always been flying wrong and they are still flying wrong, and, being females, they probably will insist on flying in just that way. So I don't think we are going to get much from the angels on flying, we have to have some of the fools fly, too.

Now, I don't know as I'll say who the fools are. I know well that Lindbergh is as near an angel as we have ever had in this country, I'll say that for him, although it is not necessary at all, we all know that.

But, now, let me see, there is another fellow, Levine. Will Rogers says you have noticed the similarity, they both begin with "L." Now, Rogers might just as well have said one ends with, say, b-sharp and one with e-flat. That is a matter of literature, or a matter of music, but it is not a matter of flying. I say that the nearest angel I have ever seen and the nearest to angels I have ever been is when I was with Kettering in this airplane, but I couldn't learn much from angels.

I noticed this in the paper just yesterday and I cut it out: "Dudley Field Malone, former Collector of the Port of New York, wants the United States to send a battleship to Europe to bring home Charles A. Levine. If he doesn't come home soon," Malone said, "we are apt to be drawn into another world war. He has the French people all upset and now he is doing the same thing in England. He is not the diplomat that Lindbergh was and the country ought to send over a battleship and bring him back."

Now, if I don't do another thing but convince you that that is just

the kind of stuff you ought to get out of the Port of New York—and it never happened in Detroit—I'll fail. "He also serves who only stands and waits" is something I never dared accept, I wouldn't dare try it. But I will say this, "He also serves who only stands and tries something, if he tries it hard and publishes the results." Let's put it that way. And I say that is what that fellow Levine is doing.

I hold no brief for Levine. I understand that he not only won't stand, but he won't even stand hitched. All I can say is that both Levine and Lindbergh are good, in their way. Maybe they are good in other people's ways. But now, between you and me, again, as man to man, what did Lindbergh teach you? What did he teach all you fellows about this wonderful success with flying? Understand, I say he is an angel, if I could imitate him I would, I am not imitating him at all. But look at the difficulty. What do you have to be to be a Lindbergh? By golly, you have to be born in Detroit first. Now, I say there aren't many people who have been born in Detroit; most everybody moved into Detroit.

Another thing, you have to be born awfully smart, of a lady chemist, a United States Senator, to be a Lindbergh, and you have to have a very stiff education and you have to walk on the wings of airplanes and you have to jump off in a parachute once in a while and land right and not hit anybody nor get hurt. And you have got to be able to write a book like "We" and sell a couple of hundred thousand copies before the thing is off the press. And you have got to be able to quiet the international situation, to say nothing of flying across. And you have to show no preference for blondes or brunettes.

Now, I say that is not only discouraging, it is terribly disheartening, and if I was going to count up the assets which I got from Lindbergh, I would say I had almost nothing which helped me to fly. I am a farmer. How could I fly with all that difficulty in my way?

I say Levine is a big experiment. He is a research proposition; he is research with capital SEARCH. There was nothing sure, it was all experimental, there was nothing thoroughly prepared, it was all difficult. Now, just pass your eye over that picture if you will, of the French flying field where Lindbergh landed, and Croyden, where more recently Levine landed. Here are these parked cars, a nice dewy evening, foggy, perhaps, all the people parking their cars, not a thing to worry about, and down comes this perfectly wonderful fellow and lands and takes out his letters of introduction and says, "We are here." No question about it, no difficulty, no worry, no experiment, no research, all done as simply as that, he didn't need a single thing, he stirred no inventive genius in France.

Stop a minute and look over what happened at Croyden after that fellow Levine got away and got off the ground. He flew over there, and as he went around the field, there were ten thousand Englishmen began thinking, began thinking right away, just as hard as they could. Now, it is something to make ten thousand Englishmen think hard,—and they thought hard. They concluded he couldn't land. Well, now, Levine was apparently the kind of a fellow that we ought to be in all of our researches,

to never think of landing, the question is to get up in the air and get over there and not worry about landing. Why, every aeronaut can land, every one has landed. Well, he is one of those fellows who just got over. But what did he show me? He showed me that a farmer could land.

Well, the English naturally thought of the last thing first, death, and they chased out the undertaker. And then they weren't dead sure that he was going to come down, anyhow, so the next thing was the ambulance, that is the next thing to death. You usually think of these things when you are doing research work, but you mustn't let them bother you or look forward, it is bad policy to publish your results and say what you are going to do, as Lindbergh does. The Lord will provide or something will happen, so you will get down. Well, here is Levine running around in the air and out comes the ambulance and it chases around and chases around to try to get where it can bring him down,—but nothing happens.

In a few minutes they think of another scheme,—their minds are acting fast. They get out the fire engines. Now, they are going to try to put him out, evidently, that is all you can say. (Laughter). But Levine doesn't seem to be one of those fellows you can put out. I think if he had stayed up a little longer, they would have invented some nets and some portable landing stations. But he came down too soon, the experiment was not a complete experiment.

As I say again, man to man, and on the quiet, that kind of a fellow who doesn't figure too close how he is going to land but sacrifices everything,—remember, he deceived his wife,—think of it! he deceived his wife to get a start, and when he went to Europe and landed, he didn't even take a passport with him. Now, a man who starts off with no passport to any place, either here or hereafter, is a real scientific research man, with the emphasis on the Research.

My feeling is that there is honor enough in this world for everybody, there is glory enough, and I would like to see that Croyden field paved, let's say with synthetic silk, and painted with Duco or some of these modern things in memory of that fellow who hired all the experts but did what he darned pleased after he had paid the experts. That is research, too.

If I can leave with you just this bare thought, that it isn't easy to do research, there isn't any royal road, it is difficult, and good research men do take their lives in their hands, and I can say just a word for that poor fellow Levine by saying there is probably glory enough for all of us, I can just add that I am glad to take my little portion of glory. Thank you.

EDGAR A. GUEST: Dr. Whitney, in your opening statement you made a remark about Mrs. Guest being pleased with me. Yeh! She and I were walking down the street one day and we passed a pretty girl. I thought the young lady tossed a smile my way, so I strutted a little and said, "Did you notice the queen smile as she went by?" And the wife said, "That's nothing; the first time I saw you, I laughed right out loud."

As to Mr. Lindbergh, we were talking about him after his glorious adventure and one of the boys in the crowd said, "Just think, he went alone and he struck Ireland within three miles of the point that he intended

CHARLES F. KETTERING

to strike,'' and one of the other boys said, ''Yeh, and if he had had an expert with him, he would have been 25 miles out of the way.''

I just had a wire from Chicago that it is a little misty over there and they are waiting a few minutes. I don't believe in killing time waiting for a couple of bruisers to get busy. You know, the thing that I have long waited for myself is about to happen. I have known this man Kettering for a great many years. I wish it were to be my privilege to present

him to you, I should like to tell you some of the things I think about him, but I am going to let your President do that. President Harper, will you introduce to us a man whom everyone in Detroit loves.

PRESIDENT HARPER: Mr. Guest, ladies and gentlemen and fellow members: It has not been my privilege to know Mr. Kettering as Mr. Guest does. I would probably be a little hesitant about standing upon my feet and telling some of the things that Mr. Guest might tell. Nevertheless, Mr. Kettering's place in the automotive industry has been great. The work of his laboratories and the work of he himself towards the development of our work in the heat treatment and handling of metals has been unsurpassed. It is the automotive industry that has made the heat treatment and the advancement of steel what it is today. It therefore gives me great pleasure to present to Mr. C. F. Kettering Honorary Membership in the American Society for Steel Treating.

C. F. KETTERING: Ladies and gentlemen: It certainly is a great honor to be made an Honorary Member of your Society, and especially with so learned a gentleman as Dr. Whitney. Of course, we agreed that we would say things like that about each other out here.

We came to the conclusion tonight that we knew less about steel treating than anybody else in the world, so we came to the conclusion that this A. S. S. T. perhaps meant, ''Are Some Steel Treaters,'' see, because, you know, we also belong to the Society of Automotive Engineers, whose initials are S. A. E., and that stands for ''Some Are Engineers,'' so perhaps that is what your initials mean, too.

Now, in every industry you arrive at a certain point and you wonder where you are going to go from there, but we sometimes don't know, and therefore we write these learned papers to show that we know where we are going, and after reading some of them, I sometimes feel a good bit like the Kentuckian who gave us directions one time when we were down in one of the little byways of Kentucky, feared we were lost, and we met this fellow and said to him, ''We want to get to Cincinnati. How do we go?''

He said, ''Well, you go right up here to the fork of the road, then, well,'' he said, ''you can take either the right or the left-hand fork; but,'' he said, ''do you know, if I was going to Cincinnati, I would never start from here.''

In this research road we have to start from where we are, and so I think that we would better start from here and listen to that fight, although I did read in the paper this morning that some minister had gotten a little flock together over in Cleveland and asked the Lord to stop it, and so I am looking to this fight as very much of an experiment, because we will see whether the minister had a good connection or not.

These scientific associations are truly wonderful things, because they are bringing the engineers and the scientific fellows together and they are making them more nearly human beings than they otherwise are. You know, they are a bunch of grouches in their particular places, but you get them out here and they have a good time,—and Detroit is a good place

to have a convention because it is on the Detroit River here, it is wet on one side and dry on the other. We haven't found out which side is which yet, but, nevertheless, you will find a lot of inspiration here in Detroit and it is a good place to have these meetings. I am only a part-time citizen of Detroit, but, nevertheless, I love this city, because I have been coming here every week for the last fifteen or eighteen years; so I know the whole scientific bunch in Detroit will be welcome.

It is only by these exchanges of ideas and working these things out that this wonderful thing we call industry progresses. The scientific fellows today are being questioned as to whether or not they have a legitimate place in the economics of things. I was questioned by one of our great American bankers as to whether or not the scientific men were not a great detriment to our country instead of being an asset, especially in the automobile business, because he said we were all the time changing models and then your car was obsolete before you had the second payment made on it. And so I told him that I didn't think that was so. He said, "Well, last night I drove my car home and I was perfectly satisfied with it, and when I got home, I found an engraved invitation to visit a show room, which I did this morning. Now, my car was running beautifully last night, but after I saw the new models, I don't like my old car so well; in fact, I think I would trade it in, but they won't allow me within two hundred dollars of what I think I ought to get for it."

I said to him, "Well, what are you going to do about it, anyway?"

"Oh," he said, "I suppose I will buy the new car and take the loss."

I said to him, "You don't take any loss. Your car is just as good today as it was last night, isn't it? The only thing that has been changed since last night is your mind, and it is worth $200.00 to have your mind changed any time. It is mental appreciation instead of car depreciation."

We are the people who are appreciating people's minds, and the scientific world is the representative of dissatisfaction. In other words, we keep people dissatisfied with what they have, and that is a wonderful thing, because just as soon as you are satisfied with what you have, then progress stops, and while you may think you depreciate your car and depreciate the old things, yet, in reality, it is that dissatisfaction with what you have that makes us work, that makes us progress, and that is what makes prosperity, because if we don't become dissatisfied, if we don't buy the new thing, we keep what we have; and if we are perfectly satisfied with that, when we do that, then we must accept the sister of dissatisfaction, which is cut-throat price competition and depression in business.

You people stand today for advanced work, and we hope that every year you can come along and make us dissatisfied with our old method of steel treating. It may mean scrapping machinery and all that kind of thing, but the net result will be of so much greater value than the old thing!

We were discussing tonight a section of the United States which seems to be more or less worried about their industrial situation. That is the finest thing in the world, to be worried about your own situation, and we

have a motto hung up in our laboratory which says, "There is Nothing So Fruitful of Thought as the Sheriff." In other words, when you have to do something, somehow, some way, your mind unshackles itself and gets to thinking, and it is these competitive things that we have, of one fellow doing something and another fellow says, "I can do better than that," that has made our industry develop into this wonderful thing that it has developed into.

Last year we produced an automobile in America for one-tenth the number of man hours required in Europe. Or, to put it another way, the European worker has to work ten times as long to get an automobile as we do in this country. So all of this thing that you are doing here is done in the spirit of progress and the scientific man today is being recognized as he never was before.

It is a great pleasure and a great honor to be associated with your organization, and if we can be of any assistance to you, by presenting a subject of which we know nothing for you to work out,—because—and I do not presume to speak for Dr. Whitney now,—I find that the most important function of a director of a research laboratory is to know very little about your subject, because then you think of things unreasonable to do, and while they sound unreasonable at the time, your boys are smart enough to work them out and then you get the credit for them. As I say, I wouldn't even suggest that Dr. Whitney is in that category, but I find that a very great essential of a director of a research laboratory is to think of unusual things to do and then hire men who can do them.

Thank you.

Adjourned at 10:00 P. M.

Following adjournment of the speaking program, the Dempsey-Tunney Fight returns were received by radio installed through the courtesy of the General Electric Company.

Friday, September 23

The Friday morning technical session was presided over by R. M. Bird as chairman and J. A. Succop, as vice-chairman. Four papers were presented at this session as follows:

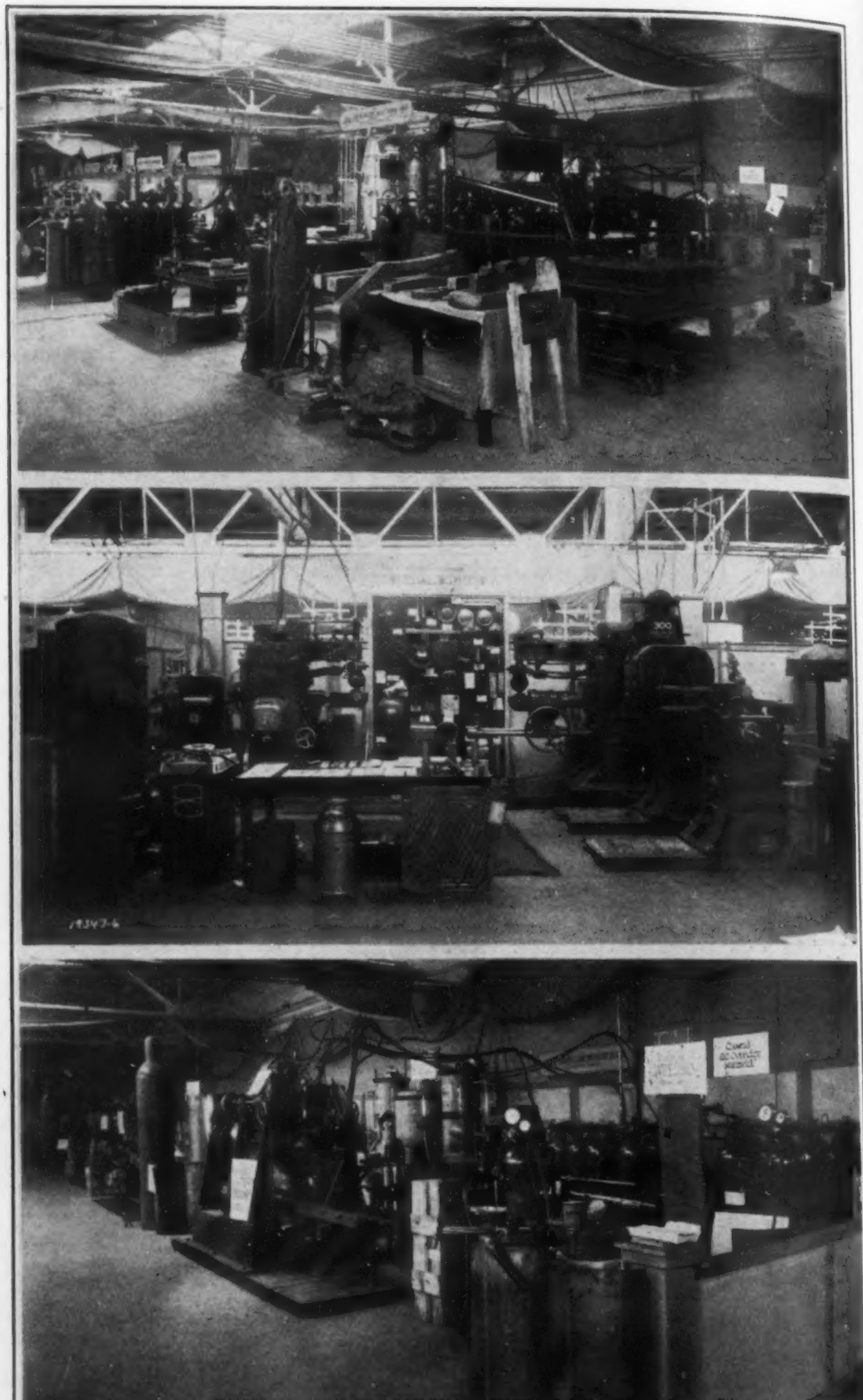
10:00—10:30 A. M.—*Design from the Heat Treating Standpoint*—G. M. Eaton, Molybdenum Corporation of America, Pittsburgh.

10:30—11:00 A. M.—*Forging Machine Die Design for Deep Piercing*—E. R. Frost, National Machinery Company, Tiffin, Ohio.

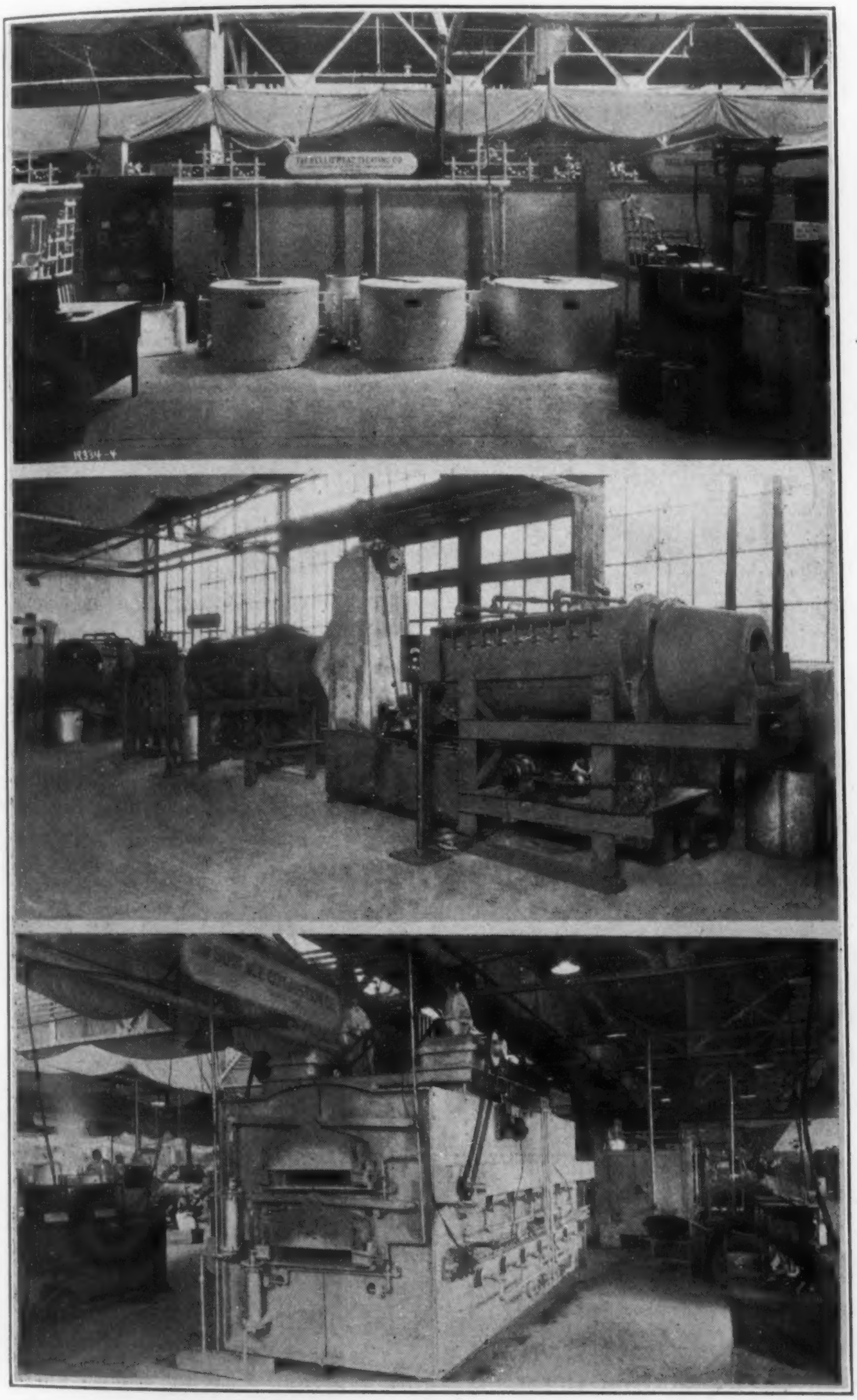
11:00—11:30 A. M.—*High Temperature Treatments of Castings and Forgings as Evidenced by Core Drill Tests from Heavy Sections*—W. J. Merten, Westinghouse Electric & Manufacturing Co., East Pittsburgh.

11:30—12:00 A. M.—*Locomotive Forging Steels*—O. V. Greene, Reading Company, Reading, Pa.

The second paper by E. R. Frost was illustrated with very fine motion pictures, showing the various operations performed by one of the latest types of forging machines.



VIEWS OF THE EXPOSITION



VIEWS OF THE EXPOSITION

The Friday afternoon session under the chairmanship of W. H. Phillips and H. M. German, as vice-chairman, was called to order at 2:00 P. M. Five papers were presented at this session as follows:

2:00—2:30 P. M.—*Relationships Between Rockwell, Brinell and Scleroscope Numbers*—R. R. Moore, Wright Field, Dayton, Ohio.

2:30—3:00 P. M.—*Machinability of Metals*—Orlan W. Boston, University of Michigan, Ann Arbor, Mich.

3:00—3:30 P. M.—*High-Speed, High-Voltage X-Ray Diffraction Analysis of Metals*—Dr. Ancel St. John, Consulting Physicist, New York City.

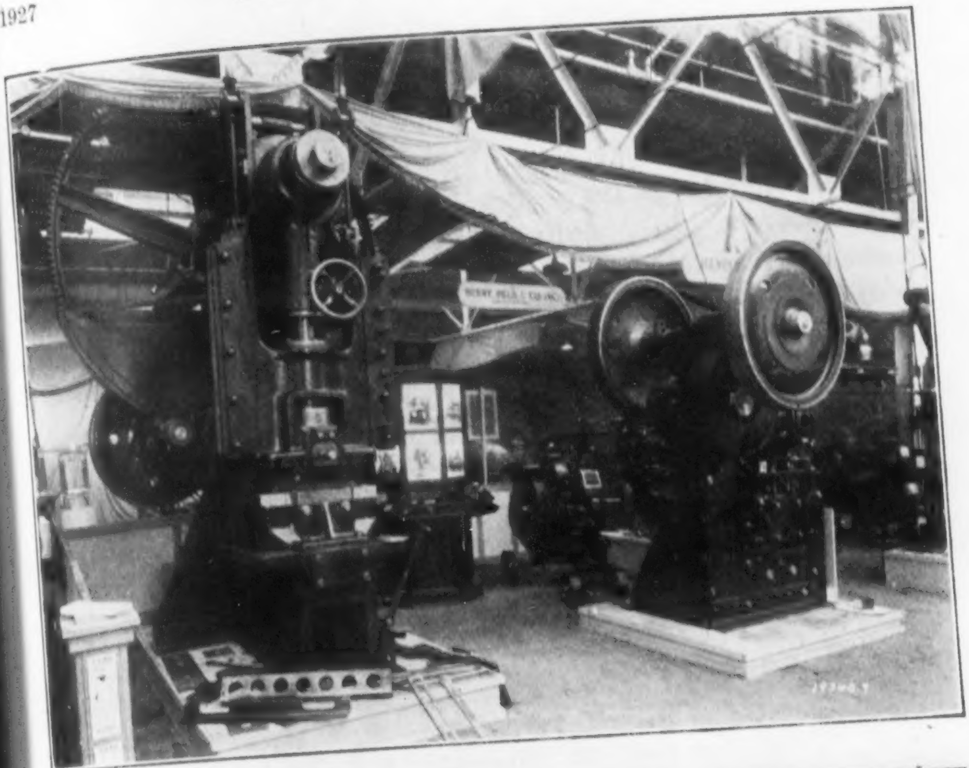
3:30—4:00 P. M.—*The Important Properties and Requirements of Some Special Refractories*—H. F. Beecher, Norton Company, Worcester, Mass.

4:00—4:30 P. M.—*Rate of Loading and Time of Application in Brinell Testing*—H. M. German, Universal Steel Company, Bridgeville, Pa.

Each of these papers was presented by the respective author, except the first one by R. R. Moore, which due to the fact that the author was not present, the paper was read by title only. Each of the above papers will appear in TRANSACTIONS, together with the oral and written discussion which followed.

Plant Inspection

Much interest was shown in the diversified inspection trips which had been arranged as part of the program for the members and guests of the Society. This program for the most part was scheduled for the afternoons of Tuesday, Wednesday, Thursday and Friday. The companies which opened their factories and laboratories to our members are as follows: Cadillac Motor Car Company; Detroit Steel Products Company; Dodge Brothers, Inc., Ford Motor Company—Dearborn, Ford Airport and Stout Metal Airplane Company; Lincoln Motor Company; Hudson Motor Car Company; General Motors Research Laboratories; Detroit Seamless Steel Tubes Company; Victor-Peninsular Company; General Motors Proving Ground, Milford, Michigan; Chevrolet Motor Company's Forge and Axle Plant; Fisher Body Corporation; Ford Motor Company-Fordson-Formerly River Rouge Plant; American Brass Company; Detroit Edison Company-Trenton Channel Plant; Packard Motor Car Company; Parke, Davis and Company; Michigan Malleable Iron Company; and The Studebaker Corporation.



VIEWS OF THE EXPOSITION

Golf Tournament

The annual golf tournament of the A. S. S. T. was held at the Hawthorne Valley Golf Club, Tuesday, Wednesday, and Thursday of National Metal week; approximately one hundred players entered and the scores show that the society has some excellent players. In awarding the prizes, the committee found that in some of the events there were several ties and these were decided by draw. In no case was a contestant allowed more than one prize.

The results were as follows:

1st Low Gross	79	*F. Connell
2nd Low Gross	79	L. E. Ruby
3rd Low Gross	81	*C. P. Burgess
4th Low Gross	81	D. A. Currie
1st Low Net	64	G. Van Dyke
2nd Low Net	67	A. E. Thornton
3rd Low Net	69	*L. D. Wurster
4th Low Net	69	*C. A. Peck
1st Low Gross 1st Nine	41	Howard Maguire
1st Low Gross 2nd Nine	40	W. E. Pratt
1st Low Net 1st Nine	32	L. C. Jacobus
1st Low Net 2nd Nine	34	*A. H. Kingsbury
Lowest Number of Putts	29	*L. A. Rowland
Most Birdies	1	*A. C. Stepan
Most Par Holes 1st 9	4	*F. H. Lovejay
Most Par Holes 2nd 9	4	C. E. Ellicott
Most Par Holes 18	6	J. E. Fick

*Won on Draw.

Ladies' Entertainment

More than 200 visiting ladies and guests were entertained with interesting sightseeing trips, luncheons, card and theater parties during the week of the convention. This feature of the program of the Society has met with much success and is a feature which is looked forward to each year by the ladies whose husbands are members of the Society. This year the program was as follows:

Monday,	September 19—	Registration at Hotel Statler. Luncheon, Hotel Statler and auto ride around the city.
Tuesday,	September 20—	Option of Bridge party, Hotel Statler, or personally conducted shopping tour of Detroit stores. Midnight theater party, State Theater.

Wednesday, September 21—Automobile ride at 11:00 o'clock.
Luncheon and Musical, Detroit Yacht Club, at 1:00 o'clock.
Grand Arabian Ball, Ball Room Hotel Statler.

Thursday, September 22—Matinee at Bonstelle Playhouse.
Annual Banquet of American Society for Steel Treating, Hotel Sattler, at 7:00 P. M.

Friday, September 23—Ladies free to entertain themselves.

AMERICAN WELDING SOCIETY

The American Welding Society meeting simultaneously and in co-operation with the American Society for Steel Treating, held their technical sessions in the Book-Cadillac Hotel. A comprehensive group of papers on welding had been arranged and scheduled for presentation in accordance with the following program.

Tuesday, September 20

10:00 A. M.—Technical Session, Book-Cadillac Hotel.
Welding the Aircraft Structure—J. B. Johnson, Chief Material Branch, War Department, Air Corps, McCook Field.
Welding in Aircraft Construction—W. C. Maylor, Chief Engineer, Stinson Aircraft Company.
The Bend Test as Applied to Welded Coupons—W. B. Miller, Union Carbide & Carbon Research Laboratories.

2:00 P. M.—Technical Session—Book-Cadillac Hotel.
Report of San Francisco Section's Investigations on "Study of Welds Subjected to High Temperature."
Heat Treatment by the Oxyacetylene Flame—E. E. Thum, Associate Editor, Iron Age.
A Metallurgical Study of Welds—G. R. Brophy, Research Laboratory, General Electric Company.

Wednesday, September 21

10:00 A. M.—Technical Session—Book-Cadillac Hotel.
Car Welding—Victor Willoughby, General Mechanical Engineer, American Car and Foundry Company.
Automobile Welding—W. C. Happ, Chief Engineer, Dept. Methods and Standards, Studebaker Corporation.

2:00 P. M.—Inspection Tours to the River Rouge Plant of the Ford Motor Company and to the Ford Airport.

7:30 P. M.—Meeting of Structural Steel Welding Research Committee, Book-Cadillac Hotel.

9:30 P. M.—Grand Arabian Ball with American Society for Steel Treating, Hotel Statler.

Thursday, September 22

10:00 A. M.—Technical Session—Book-Cadillac Hotel.
Study of Oxyacetylene Welding as Applied to Light Gage Pressure Containers—H. J. Grow, Air Reduction Sales Company.
Welding in the Design of Steel Plate Work—L. J. Sforzini, Engineering and Maintenance Department, Eastman Kodak Company.

2:00 P. M.—Technical Session—Book-Cadillac Hotel.
Welding of Structural Steel—Joseph Matte, Jr., of Albert Kahn, Inc.

A Recent Addition to the List of Arc Welded Buildings—G. H. Danforth, Contracting Engineer, Fabricating Section, Jones & Laughlin Steel Corporation.

6:30 P. M.—Annual Fall Dinner Dance of the American Welding Society, Book-Cadillac Hotel.

At the board of directors meeting held Monday afternoon it was decided to hold the 1928 fall meeting and the fourth welding exhibit of the American Welding Society in Philadelphia, concurrently with the National Metal Exposition.

SOCIETY OF AUTOMOTIVE ENGINEERS PRODUCTION MEETING

The annual Production Meeting of the Society for Automotive Engineers held in the Hotel Statler, Detroit, September 21 and 22 consisted of the three sessions, the first one being held at 2:00 P. M. Wednesday, the second at 8:00 P. M. Wednesday and the third at 8:00 P. M. Thursday. The papers which were presented and discussed are as follows:

Steel Session

Frank P. Gilligan, Chairman

2:00 P. M.—*Relation of Metallurgy to Production*—J. M. Watson, metallurgist Hupp Motor Car Corporation.

Frequency Curves as a New Basis for S. A. E. Physical Property Charts—E. J. Janitzky, metallurgical engineer, Illinois Steel Co.

Developments in Grinding—A. O. Knight, Norton Co.

Evening Session

John Younger, Chairman

8:00 P. M.—*Production Engineering*—A. R. Glancy, president, Oakland Motor Car Co.

Fire Hazards Incidental to the Spraying of Inflammable Finishes—H. E. Miner, E. I. du Pont de Nemours & Co.

The motion picture, *The Age of Speed,* was shown following the paper by Mr. Glancy.

Time Study Session

Eugene Bouton, Chairman

8:00 P. M.—*Relation of Time-Study to Management*—J. C. Mottashed, Hudson Motor Car Co.

Relation of Time-Study to Labor Budgets—E. J. Frounfelker, Continental Motors Corp.

INSTITUTE OF METALS DIVISION OF THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

The Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers held their annual fall meet-

ing in Detroit during National Metal Week. Three technical sessions were on the Institute program, one of which was a joint session with the American Society for Steel Treating. The technical program of the Institute is as follows:

Meeting—Book-Cadillac Hotel

10:00 A. M.—*The Condition of the Thorium Content of Thoriated Tungsten Filaments*—Ancel St. John.
X-Ray Analysis of the Plastic Deformation of Zinc—T. A. Wilson and Samuel L. Hoyt.
Quantitative Spectrum Analysis—F. Twyman and D. M. Smith.
Production of Metallic Single Crystals—J. A. M. Van Liempt.
Twinning in Ferrite—L. W. McKeehan.
6:30 P. M.—Executive Committee Meeting—Book-Cadillac Hotel.

WEDNESDAY, SEPTEMBER 21

2:00 P. M.—Joint Session of Institute of Metals and the American Society for Steel Treating Meeting—Book-Cadillac Hotel.
W. R. Webster, chairman
Commercial Forms and Applications of Aluminum and Aluminum Alloys—P. V. Faragher.
Machining Aluminum—R. L. Templin.
Physical Characteristics of Commercial Copper-Zinc Alloys—W. H. Bassett and C. H. Davis.
Nickel and Monel Metal—C. A. Crawford.
Wrought Zinc—C. S. Trewin.
7:00 P. M.—Banquet, Book-Cadillac Hotel.

THURSDAY, SEPTEMBER 22

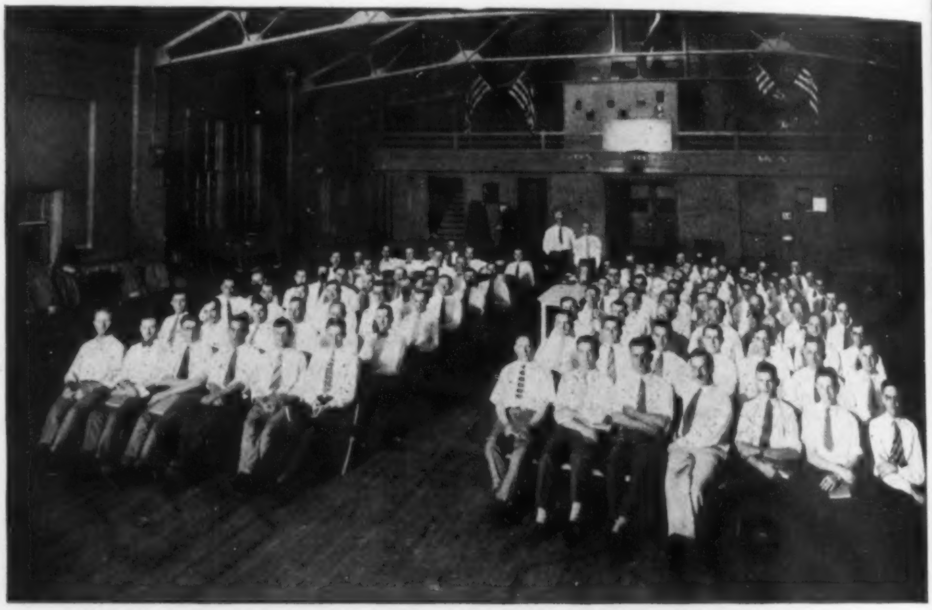
10:00 A. M.—Technical Session—Meeting Book-Cadillac Hotel.
Dr. S. L. Hoyt, chairman
Some Aspects of the Commercial Manipulation of Aluminum—C. F. Nagel, Jr.
Equilibrium Relations in Aluminum-Silicon and Aluminum Iron-Silicon Alloys of High Purity—E. H. Dix, Jr., and A. C. Heath.
Heat Treatment of Aluminum-Silicon Alloys—R. S. Archer, L. W. Kempf and D. B. Hobbs.

On Wednesday evening the Institute held its annual fall meeting banquet which was attended by about 100 members and guests. After a short business meeting Mr. E. Blough, technical director, Aluminum Co., of America, was the speaker. Mr. Blough discussed the general technical aspects of the Aluminum industry, referring to the recent developments in aluminum and its alloys. His close association with the Aluminum company for many years, during which the development of duralumin was in progress, has made him intimately familiar with light alloys. These interesting glimpses at metallurgical activities are becoming increasingly popular at the Institute of Metals Dinners.

EXTENSION LECTURES

DURING the summer, the Board of Directors arranged with Purdue University for the loan of Prof. John F. Keller to conduct a series of extension lectures on "Steel and Its Treatment" with the cooperation of the University. Mr. Keller's first classes included Dayton, Columbus, Canton-Massillon, Youngstown and Erie, one lecture a week in each city for a series of six weeks. The experiment has proven to be a success.

Mr. Keller is well known to a large number of our members. He was president of the Steel Treating Research Society at the



Dayton Lecture Group Attending Engineering Extension Courses Presented by Professor Keller

time of the merger which resulted in the A. S. S. T., back in 1920. For years, Mr. Keller has been connected with Purdue University in the Engineering Extension Division, where he has conducted throughout Indiana hundreds of extension lecture courses before more than 3600 men and covered "Steel and Its Treatment."

He came up through the ranks as a blacksmith, and iron and steel worker. Then by persistently delving into the intricacies of the underlying theory, he acquired that nice balance between theory and application that is so much sought after by busy men.

All who have heard Mr. Keller speak before chapters of the A. S. S. T. will recall his pleasing delivery, his many unique but

simple pieces of demonstration apparatus, and the clear picture he paints of a very complex subject. The Society is fortunate in now having this service available for many of the industrial centers of this country.

Mr. Keller gives six lectures covering (1) the manufacture of iron and steel, (2) the "spark method" of selecting iron and steels, (3) annealing and refining of crystalline structures, (4) the solid solution theory, illustrated by the iron-carbon diagram, (5) the various quenching media, and (6) why iron and steel warps and cracks. All are illustrated with lantern slides, movies and ingenious special demonstrations.

One more series of talks will be given before Mr. Keller returns to Purdue for the year on January first. This series will include Chicago, Tri-Cities, Milwaukee, Rockford and one other city in this general territory. The service is rendered at a little less than cost, $10.00 per man, to any interested person. This includes the selection by the individual of four dollars worth of A. S. S. T. publications. The total enrollment in the first series of lectures is 366 and is divided as follows: Dayton 99, Canton-Massillon 93; Erie 67, Youngstown 59, Columbus 48.

This includes presidents, purchasing agents, managers, accountants, foremen, superintendents, shopmen, engineers, metallurgists, chemists, etc. It is essentially a body of very busy men who are seeking an understanding of the behavior of iron and steel.

ARTHUR G. HENRY

It is with deep regret the Society records the loss of one of its founder members, Mr. Arthur G. Henry, whose sudden death occurred in Chicago on Wednesday, October 5th.

Mr. Henry was probably the best known member of the Society, having been one of a small group of men instrumental in forming the Chicago section of the Steel Treating Research Society and later taking an active part in the formation of the American Steel Treater's Society and serving as the first secretary of the Chicago chapter as well as the first secretary of the national organization which was formed with the Chicago chapter as a nucleus.

Since those days "Arthur", as he was affectionately known to all, has given his best to further the cause and aims of the Society. Probably his most outstanding contribution was the "fathering"

of an exposition under the auspices of the American Steel Treater's Society, which was the first of its kind ever held in America and held at the Seventh Regiment Armory in Chicago about 9 years ago.

This exposition from its small beginning in 1919 has become one of the recognized annual events of the Iron and Steel World

Arthur G. Henry

and one of the largest industrial expositions held in America.

Mr. Henry has served, with the exception of two years, continuously as secretary of the Chicago chapter where his enthusiasm, attention to detail, wide acquaintance, and friendly spirit, have filled a niche in the hearts of all the members that time itself will not be able to eradicate.

In 1925 Mr. Henry was elected a Founder Member in the American Society for Steel Treating, and his membership was conferred at the annual meeting at Chicago in 1926.

Mr. Henry's death has created an aching void which can only be assuaged by the pleasant memories of a life of usefulness and work for others.

ON GRAIN GROWTH IN MILD STEELS

By Yap Chu-Phay

Abstract

This paper presents new data on the grain-growth of ferrite in mild steels (containing about 0.10 per cent carbon) upon annealing. It discusses the nature and possible cause of the differences from the results of previous investigations.

In this paper the writer proposes a theory of grain-growth in mild steels, based on the hypothesis that a boundary film exists, in which the carbide is colloidally dispersed, and he discusses the relation of the boundary film to the structural changes in steel upon annealing. He also presents certain inferential evidence supporting the hypothesis. Other experiments predicated on the theory are shown to yield consistent results that may be interpreted only as a strong substantiation of the hypothesis. A slight age-hardening in the steel under investigation is noted and discussed.

A method of producing coarse grains by holding the steel sample above A_3 for a certain length of time and then controlling the rate of cooling through the upper critical range, is described and discussed. Experimental evidence indicating the probable relation of germination (Sauveur's type) to the presence of the boundary film in mild steels, is presented, but no definite explanation is offered at this time.

FOR convenience this paper is divided into two parts. Part I is concerning general experiments on grain-growth in mild steels by annealing, and Part II gives a proposed theory of grain-growth in mild steels, including some special experiments based on the theory. The work described in Part I covers the ordinary grain-growth studies and the comments therein are confined to the observations made during these studies. The theoretical interpretation of these data is, however, included in Part II, which presents the main argument of the paper. In Part II a theory of grain-growth is proposed, based on the hypothesis of the existence of a boundary film in which the carbide is colloidally dispersed. The hypothesis

The author, Yap Chu-Phay, is metallurgical engineer, with the American Machine and Foundry Co., Brooklyn, New York. Manuscript received June 30, 1927.

was evolved as a result of the studies described in Part I and is developed in full in Part II.

Part I, General Experiments on Grain-Growth by Annealing

In making an extensive study on grain-growth in mild steels (strips of about 0.125-inch thick) with a view to coarsening the structure, the writer was surprised to discover the steel did not show as appreciable growth as was anticipated on theoretical grounds. Thus, for example, a fine-grained structure should coarsen more than an already coarse structure. According to Benson and Thompson[1] and Joisten[2], growth is very rapid within the first five hours at annealing temperatures of 932, 1112, and 1292 degrees Fahr. (500, 600, and 700 degrees Cent.). Messrs. Benson and Thompson found little growth at 1472 degrees Fahr. (800 degrees Cent.) and Joisten also concluded from his experiments that growth reaches a maximum at 1292 degrees Fahr. (700 degrees Cent.).

Samples from three different heats were obtained and their chemical analyses in per cent were as follows:—

	Carbon	Manganese	Phosphorus	Sulphur	Silicon
(a)	0.11	0.43	0.012	0.030	0.02
(b)	0.10	0.43	0.012	0.030	0.02
(c)	0.09	0.36	0.010	0.028	0.02

As a preliminary study, the writer annealed various samples for 6 hours at 750, 850, 950, 1050, and 1150 degrees Fahr. respectively (400, 454, 510, 565, and 620 degrees Cent.) and found hardly any grain-growth had taken place. It was then decided to make a systematic study of grain-growth in this kind of steel. Since the behaviors of the three steels were alike, only steel (b) was used in this investigation.

The critical points of steel (b) were as follows:—

	Degrees Fahr.	Degrees Cent.
Ac_1	1,350	734
Ac_2	1,410	765
Ac_3	1,610	876
Ar_1	1,260	670
Ar_2	1,408	765
Ar_3	1,552	842

[1]Benson and Thompson, Journal Iron and Steel Institute, No. 1, 1923, p. 525.

[2]Joisten, Metallurgie, Vol. 7, 1910, p. 456.

The hardness obtained on a 500 kilogram Brinell machine was around 80, which is slightly softer than pure iron. Upon annealing even for only 15 minutes, the hardness dropped down to 74.

The results of the present study are shown in Fig. 1. The results from the 752 and 932 degrees Fahr. (400 and 500 degrees Cent.) anneal are insufficient to plot definitely their temperature-growth curves, and so only those for the 1112, 1292, and 1472 degrees Fahr. (600, 700, and 800 degrees Cent.) anneal are drawn.

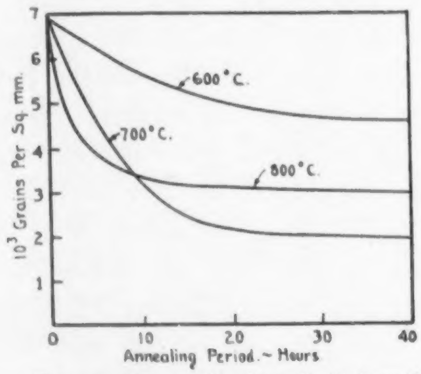


Fig. 1—Curve Showing Grain-Growth of Ferrite in Mild Steel.

The Heyn "intercept method" was used in the grain counts as the structure was so fine that any error by this method of counting would be rather small.

It was observed that some germination took place at 1292 degrees Fahr. (700 degrees Cent.) and that the carbide showed distinctly a tendency towards a spheroidized condition. The writer was able to produce a coarse structure (about 2000 grains per square millimeter) in a sample merely by slowly cooling through Ac_1. In the case of an Ehn test, the growth was very rapid so that after only 2 hours at 1706 degrees Fahr. (930 degrees Cent.) the number of grains per square millimeter fell off to only 1200, but further annealing did not, however, coarsen the structure appreciably. Samples annealed at 1652 degrees Fahr. (900 degrees Cent.) for 1 hour showed hardly any grain-growth, but those held at that temperature for 3 hours and 5 hours respectively showed a structure containing about 1500 grains per square millimeter. Upon chemical analysis, however, these samples showed an appreciable decarburization (relatively speaking, of course), which thus casts some doubt on the results. Nevertheless, it would be quite reasonable to believe that grain-growth at 1652 degrees Fahr. (900 de-

grees Cent.) would be more rapid than at 1292 degrees Fahr. (700 degrees Cent.) and that equilibrium grain-size would also be more rapidly attained.

PART II, A PROPOSED THEORY OF GRAIN-GROWTH IN MILD STEELS, INCLUDING SOME SPECIAL EXPERIMENTS

Theoretical Discussion

Under normal conditions when a mild steel cools down through the critical range, ferrite is precipitated until at Ar_1 the remaining austenite of eutectoid composition changes into pearlite, which is interspersed in the ferrite matrix. However, a microscopic and chemical study of the steel under investigation revealed all the ferrite grains to be enveloped by the carbide phase, that is, by "boundary cementite."[3] The phenomenon of boundary cementite or carbide is common in mild and low-carbon steels. It represents a case of extremely rapid cooling through the critical range, resulting in the delayed precipitation of the carbides constituent after the ferrite grains are already formed. When the grains are very coarse and the carbon content is high, we would have a Widmanstätten structure. The logical inference of the phenomenon of boundary cementite in mild steels is that the carbide was temporarily dissolved in the ferrite grain-boundary when the steel is cooled rapidly through A_1. It is precisely this condition of extremely rapid supersaturation and equally rapid precipitation that would cause the carbide to crystallize in particles of colloidal dimensions, or that a colloidal suspensoid would thereby result. The condition of rolling, with the attendant rapid drop in temperature, precludes the possibility of the formation of lamellar pearlite.[4] It may be noted here that when pearlite existed at all, which was seldom, it was in a form known as sorbitic pearlite (Arnold). From our knowledge of the mechanism of crystallization of iron and steel, it is reasonable to infer that upon rapid cooling through the critical range, the grain-boundary region represents the portion last transformed from austenite into ferrite (vice versa, upon heating) and hence, it follows that the carbide distribution will be along the intercrystalline boundary of the ferrite grains.

[3]Pilling, *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 70, 1924, p. 254.

[4]Consult Sauveur's The Metallography and Heat-Treatment of Iron and Steel, pp. 49-52, on pearlite in low-carbon steels. Also note the evidence of a slightly emulsified condition of the pearlite in a 0.20 per cent carbon steel (page 51).

In order to have a clear view of the working of the writer's proposed theory of grain-growth in low-carbon and mild steels, it seems necessary to present an exposition of the mechanism of the transformation and grain-growth that occurs upon heating and cooling through the critical range. On the basis of 0.10 per cent carbon, we have about 1.5 per cent Fe_3C which under normal conditions will be associated with about 10 per cent ferrite to form 12 per cent pearlite. At 1292 degrees Fahr. (700 degrees Cent.) 12 per cent of the structure is fundamentally affected, but at 1472 degrees Fahr. (800 degrees Cent.) four times as much of the structure is affected, and therefore more growth is to be expected. A study of Fig. 1 shows, however, that, although growth is more rapid at first in the 1472 degrees Fahr. (800 degrees Cent.) anneal, there is more growth in the 1292 degrees Fahr. (700 degrees Cent.) anneal after 8 hours. Samples held at 1292 degrees Fahr. (700 degrees Cent.) for a long time showed the effect of annealing on both the ferrite and the carbide phase: the former showed germination or differential growth and the latter showed a distinct tendency towards spheroidization. The apparent coalescence of the very minute carbide spherulites was most probably due to slight diffusion in the solid state. The tendency in a carbon steel heated below the critical range, according to Davey,[5] is to form aggregates of Fe_3C due to the migration of the carbon atoms through the interstitial channels in a body-centered cubic lattice (alpha iron).

Precisely because the carbide is distributed in the intercrystalline boundary of the ferrite grains, the austenite first formed will occupy the same position and subsequent growth will be governed accordingly. This continual dilution of the austenite, due to the progressive change of ferrite into gamma iron, takes place by gradual absorption of the ferrite grains on all sides, thus making the austenite more and more the continuous phase and the ferrite the dispersed or discontinuous phase. At this point, the structure is essentially that of ferrite embedded in an austenitic matrix. The writer is firmly convinced that only infrequently are ferrite grains completely absorbed and then only by their own kind as a result of coalescence. The tendency of the austenite phase thus formed is immediately to decrease its total surface so that instead of a continuous austenite phase with the ferrite dispersed, we would normally have two segregated phases interspersed in the structure.

[5]Davey, General Electric Review, Vol. 29, June 1926.

If such a condition really existed, then it would be reasonable to expect considerable grain-growth shortly after A_1 is passed. The results of the present investigation, as well as of the aforementioned researches by others, do not, however, bear this out. As only little growth takes place, we may reasonably believe that the austenite phase remains continuous, and, that upon cooling, it agains breaks up into numerous ferrite grains, so that at just above A_1, the eutectoid austenite is located in the intercrystalline boundary of the ferrite grains and the carbide would be precipitated as before when A_1 is passed.

The assumption that the carbide is in a colloidal state of suspension in the boundary film supplies us with a rational explanation of the recalcitrant behavior of the grains. Under the general condition of pearlite grains interspersed in the ferrite matrix, we can easily imagine growth of ferrite taking place by merely progressive change of orientation of one ferrite grain with respect to another (Carpenter and Elam). If the carbide were not in a colloidal condition, but were situated as envelopes around the ferrite grains, these grains could still grow easily as a result of the aggregation of the carbide particles when A_1 is passed. On the basis of the assumption that a carbide colloidal suspensoid exists, the carbide particles are never in actual solution in gamma iron either atomically or as Fe_3C molecules. Precisely because these particles are large, compared to the carbon atoms or even the Fe_3C molecules, there is hardly any opportunity of inducing the migration of these particles through the interstitial spaces, so that this colloidal film acts as an inert phase separating the ferrite grains from one another, and thus preventing grain-growth. We must remember that the location of austenite is governed by the location of the carbide; if the continuous film of carbide is not destroyed when the steel is heated to above A_1, then the austenite formed will also be a continuous film, which at a higher temperature becomes a continuous phase around the ferrite grains. It is for these reasons that the writer's results for the 1112 degrees Fahr. (600 degrees Cent.) anneal shows much less grain-growth than was obtained by Benson and Thompson and also by Joisten. In this way, the slow growth at 1472 degrees Fahr. (800 degrees Cent.) may also be accounted for. The writer is inclined to the opinion that the maximum growth observed at 1292 degrees Fahr. (700 degrees Cent.) is intimately related to the temperature of recrystallization. It is at

just below A_1 that the effect of recrystallization on the grain-size would be most effective. The large austenite grains formed by an anneal above A_1 would most likely be broken up into smaller grains when the steel is cooled through the lower critical point.

The Structure of the Boundary Film

The writer has yet formed no definite opinion regarding the real structure and the chemical composition of the boundary film in which the carbide is colloidally dispersed. It may be associated with the so-called amorphous cement in the intercrystalline boundary of the ferrite, or with other impurities inherent in steels. Perhaps the protective action is due to the eutectoid of iron-carbon-oxygen, as proposed by my former colleague, John Gat, in a paper read last winter before this society at Washington.[6] In this paper the writer is not concerned with the chemical composition of the boundary film. He is only interested in presenting certain evidence tending to show that the carbide is colloidally dispersed in the boundary film, which inhibits grain-growth of the ferrite grains. The writer has computed from the total length of the intercrystalline boundary (on a plane surface) and from its apparent width, that the carbide film occupies about 15 per cent of the structure. It seems, therefore, as if the carbide is associated with ferrite in some form or other. If the film is a mechanical mixture of ferrite and carbide, with or without other constituents, the carbide must be in a condition similar to that in sorbitic pearlite, only more highly dispersed. Evidence tending to substantiate this supposition was obtained from residue tests.

The writer made a comparative study of the carbon residue by dissolving small samples of the differently heat treated specimens in weak sulphuric acid. The results are tabulated below: the amount of residue is compared to the residue obtained from a carburized (Ehn test) sample (= 10)

Sample	Heat Treatment	Residue
1	As received without heat treatment	0
2	At 1112 deg. F. (600 deg. C.) for 12 hrs.	0
3	At 1292 deg. F. (700 deg. C.) for 8 hrs.	2
4	At 1472 deg. F. (800 deg. C.) for 12 hrs.	0
5	Carburized (Ehn test)	10
6	Quenched from 1688 deg. F. (920 deg. C.)	0
7	Special heat treatment*	2
8	Sample 7 after a second heat treatment.*	4

*The heat treatment will be described below (K-2).

[6] TRANSACTIONS, American Society for Steel Treating, Vol. 12, September 1927.

Thus one would infer that the condition of the carbide must have been similar to that in the quenched condition, that is, to hardening carbon (Sauveur) in a very high state of dispersion. According to Heyn, hardened steel tempered above 752 degrees Fahr. (400 degrees Cent.) contains cement carbon, which would be left as residue when the steel is dissolved. However, the writer found no residue in any of the samples heat treated in the ordinary way except No. 3. As noted above, samples heat treated at 1292 degrees Fahr. (700 degrees Cent.) showed evidence of spheroïdized carbide and it is only logical to infer that the rate of coagulation of the carbide in at a maximum at this temperature. We are thus forced to conclude that even prolonged heat treatment does not sufficiently aggregate the carbide to leave any residue from the samples which were dissolved. We cannot escape the consequent inference that in such a fine state of dispersion, a colloid must have existed, whether we conceive of it on a physical or on a chemical basis. On the other hand, those samples, which were given the special heat treatment described below, showed appreciable residues, indicative of the aggregation of the carbide.

Apparent Age-Hardening

Somewhat in accord with the conclusion drawn from the residue tests is the inference one may draw from the results obtained in the hardness study. Throughout the investigation a careful check of the hardness was kept. It was felt that while the hardness itself does not throw light on the problem, still a series of progressive changes in hardness generally indicates the tendency or direction of change in other physical properties.

On account of the thinness of the strips used in these experiments, the hardness was determined on the Brinell machine at 500 kilogram load only. It was found that at all temperatures from 400 to 752 to 1652 degrees Fahr. (900 degrees Cent.) the effect of a 15-minute anneal was apparently enough to relieve cold work strain, as the hardness dropped from 80 to 74. The hardness of the samples annealed at 1112, 1292, and 1472 degrees Fahr. (600, 700, and 800 degree Cent.) for different periods is graphically shown in Fig. 2. It may be noted here that the samples annealed at 1292 degrees Fahr. (700 degrees Cent.) were somewhat variable in hardness in spots and that only the characteristic values are shown in the graph.

It is most surprising to note in Fig. 2 that the hardness increased to a maximum at some period, especially with the 1112 degrees Fahr. (600 degrees Cent.) anneal. What caused this increase in hardness was not thoroughly determined at the time this investigation was pursued. However, it is legitimate to draw certain inferences from our present knowledge of the behaviour of other alloys. It has been the erroneous assumption of several metallurgists[7] that because no pearlite is seen in steels containing less

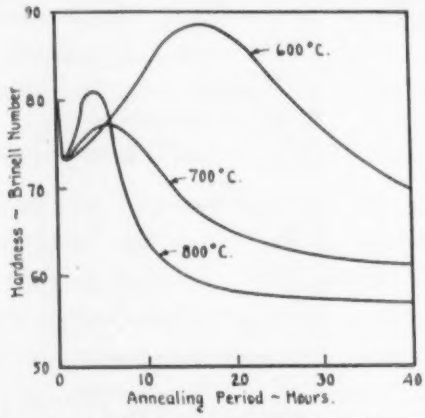


Fig. 2—Curve Showing Hardness Versus Annealing Period.

than 0.05 per cent carbon, the carbon must, therefore, be in solution in ferrite. The only correct inference to be drawn from this fact is that at the temperature when pearlite could be formed, that is, at A_1, the solubility of carbon in ferrite is about 0.05 per cent and hence, no carbon is available for the formation of pearlite[8]. We will, on the other hand, find the carbon distributed in the structure as boundary cementite or carbide, as Pilling[9] did even with a steel containing as low at 0.015 per cent carbon. Yamada[10] has recently redetermined the solubility of carbon in ferrite and found Yensen's[11] previous figures correct (that is, 0.006 to 0.008 per cent). At A_1 the solubility of carbon is between 0.035 per cent (Scott) and 0.04 per cent (Honda). The solubility curve

[7]Note, for example, Dr. Hatfield's remarks in the discussions of the papers in "The Physical Chemistry of Steel-making Processes," The Faraday Society, June, 1925, page 272.

[8]It may be noted here that R. G. Guthrie (TRANSACTIONS American Society Steel Treating, March, 1925, page 387) has obtained some microscopic evidence of the presence of pearlite in an ingot iron containing 0.02 per cent carbon. The term, "pearlite," as applied in this case is questionable.

[9]See foot note 3.

[10]Yamada, Science Reports, Tohoku Imperial University, Series 1, Vol. XV, 1926, No. 6.

[11]Yensen, Chemical and Metallurgical Engineering, Dec. 13, 1923.

of carbon in ferrite (shown in Fig. 3) should be incorporated in the Fe-C diagram proposed by Honda, which seems to be most in accord with our present knowledge of the system.

Most of the alloys that can be aged possess a solubility curve similar to that shown in Fig. 3. The apparent age-hardening in the steel under investigation may be explained as follows, whether we accept the precipitation theory or not. On account of the relatively large total intercrystalline space compared to the amount

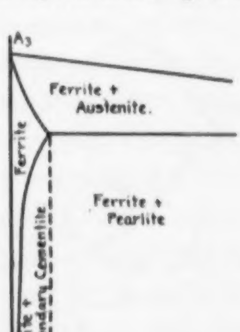


Fig. 3—Diagram Showing Solubility of Carbon in Ferrite.

of carbon in the steel, the carbide would not be evenly distributed throughout the entire structure, and the boundary film is weaker in places than in others. We must remember that at 1112 degrees Fahr. (600 degrees Cent.) at least 25 per cent of the carbide in the steel is in solution in the ferrite, so that diffusion could take place to some extent, resulting in the general strengthening of the boundary phase, therefore of the structure. A time is finally reached, however, when the so-called optimum size of the carbide in the suspensoid is passed and the boundary film becomes weaker (Alexander). Concurrent with this process is the tendency of the ferrite to grow so that as the aggregation of the carbide takes place, leaving more ferrite interface, the ferrite grains coalesce with one another to some extent.

The writer hopes to investigate further the subject of age-hardening in mild steels. In a recent paper, Messrs. Andrew and Dickie[12] suggest that temper brittleness may be due to the precipitation of carbide in the intercrystalline boundary in accordance with

[12]Andrew and Dickie, Journal, Iron Steel Institute, No. 2, 1926, p. 359.

the equilibrium diagram shown in Fig. 3. The writer has made only two simple tests on this point. A sample which was annealed at 1112 degrees Fahr. (600 degrees Cent.) for 20 hours showed an elongation of about 35.5 per cent. Another sample, which was quenched from 1688 degrees Fahr. (920 degrees Cent.) and then annealed at 1112 degree Fahr. (600 degrees Cent.) for 2 hours, showed only 26 per cent elongation. Upon microscopic examination, their grain-size was not appreciably different. This is really an interesting point that needs to be studied on a general scale. Microchemical determinations of the residue and the hydrocarbon gases evolved (similar to Professor Campbell's methods) may perhaps prove a fruitful method of attacking this particular problem.

Experimental Test of the Theory

Thus we see from the above discussion how the writer first reviewed the mechanism of recrystallization of iron and steel and of the precipitation of the carbide, and how he came to build up a theory based on the hypothesis of a boundary film in which the carbide is colloidally dispersed, by which he could explain a number of anomalies in the growth of the ferrite. While there is, as yet, no direct, positive evidence of the structure of the boundary phase, inferential evidence drawn from apparently unrelated sources all tends to substantiate the theory. A good test of a theory is in the way it reconciles known facts and predicts certain new phenomena predicated on it. Thus, according to the proposed theory of grain-growth:

(a) Little grain-growth could take place at below A_1, or between A_1 and A_3.

(b) Some grain-growth could always take place at all temperatures above A_3. In the first place, it must be remembered that decarburization would induce grain-growth. However, with long anneal the boundary film would finally be broken up and the carbide would be completely dissolved in the gamma iron, so that grain-growth is to be expected.

(c) Excellent grain-growth could take place by holding the steel at above A_3 for a short time and controlling the rate of cooling through A_3 so that the formation and uninterrupted growth of but few grains may take place (Tammann). In such an event, the carbide would be precipitated as sorbitic pearlite in the re-entrant angles of the ferrite grains.

(d) Good grain-growth could take place in a similar way by controlled rates of cooling through the entire critical range, but the important factor is the slow cooling through the A_3 range.

(e) Once the boundary film is destroyed, grain-growth could take place fairly rapidly by ordinary annealing at below A_1. The boundary film is supposed to be destroyed by the heat-treatment described above in (c) and (d).

(f) Since the carbide is never actually dissolved, if the hypothesis on which the present theory of grain-growth is based be correct, the formation of lamellar pearlite by any process of heat-treatment could not take place. On the contrary, as the aggregation of the carbide particles takes place, sorbitic pearlite or even massive cementite would be expected to form.

The first two generalizations, (a) and (b), are in accordance with the observed data given in Part I of this paper. The writer has already discussed in the earlier part of this paper how the present theory is partly predicated upon those data.

The last four generalizations constitute the most important test of the theory and the remarkably consistent results obtained by the writer from experiments to verify them are very gratifying to him. In the following table, the method of heat-treatment and the resulting structure are shown.

Sample	Heat Treatment	Grains/mm²
K-1	Held at 1670 degrees Fahr. (910 degrees Cent.) for 30 minutes and then cooled in the furnace	4500
K-2	Held at 1670 degrees Fahr. (910 degrees Cent.) for 30 minutes; cooled from that temperature to 1554 degrees Fahr. (820 degrees Cent.) in 30 minutes and the rest of the way in the furnace at a normal rate	2200
K-3	Same as K-2, but cooled through the upper critical range in 1 hour	800
K-4	Same as K-2, but cooled through the upper critical range in 2 hours	350
M-2	Held at 1670 degrees Fahr. (910 degrees Cent.) for 30 minutes; cooled from that temperature to 1300 degrees Fahr. (705 degrees Cent.) in 1 hour and the rest of the way in air	1400
M-5	Same as M-2, but cooled through the entire critical range in 2 hours	1100
M-6	Same as M-2, but cooled through the entire critical range in 3 hours	700
N-6	Held at 1390 degrees Fahr. (755 degrees Cent.) for 30 minutes; cooled from that temperature to 1300 degrees Fahr. (705 degrees Cent.) in 3 hours and the rest of the way in air.	2000

O-1	Held at 1600 degrees Fahr.* (870 degrees Cent.) for 30 minutes; cooled from that temperature to 1300 degrees Fahr. (705 degrees Cent.) in 2 hours and the rest of the way in the furnace	3300
P-1	Held at 1670 degrees Fahr. (910 degrees Cent.) for 2 hours and then cooled as K-4	2000

*1600 degrees Fahr. (870 degrees Cent.) is just below Ac_3

Thus we see from the preceding table that the rate of cooling through A_3 seems to be an important factor in coarsening the structure. But this is not the only factor; otherwise we could easily explain the growth from the generalizations of Tammann. On the basis of the present theory, the destruction of the boundary film is necessary before growth could take place. As shown in Sample O-1, when the steel is not heated past Ac_3, where the structure is completely austenitic, growth is not rapid. On the other hand, holding the steel above Ac_3 for 2 hours, as in Sample P-1, and then cooling through the upper critical range in 2 hours as in the K series, do not seem to coarsen the structure very much. This may be explained on the supposition that holding the steel at a temperature well above Ac_3 for a long time tends to destroy completely all the alpha ferrite nuclei, so that upon cooling there is a tendency towards supercooling, which in turn would increase the nuclei number. This is in accordance with Tammann's generalizations governing recrystallization and grain-growth.

The rate of growth in the K and the M series are graphically shown in Fig. 4. The curve for the K series surprisingly suggests that with very slow rate of cooling through the A_3 range, we may obtain excessively large grains, and perhaps even single crystals. The idea seems worth further experimentation, especially with a strictly controlled rate of cooling through A_3 in a highly reducing atmosphere.[13]

Stead and Carpenter[14] found that electro-deposited iron of certain thickness (about 0.011 or 0.012-inch) showed extreme coarsening when held at just above Ac_3 even for only a few seconds. On the other hand, they failed to find rapid grain-growth in mild steel and in wrought iron of high purity even by prolonged annealing at above A_3 and by slow cooling through the upper critical range. They attributed the lack of grain-growth in wrought iron to slag inclusions and in mild steel to sulphide inclusions. The

[13]Edward and Pfeil, *Journal,* Iron Steel Institute, No. 1, 1924, p. 129.

[14]*Journal,* Iron Steel Institute, No. 2, 1913, p. 119.

writer believes with them that the inclusions may influence the nuclei number in wrought iron to some extent, but it does not seem logical to blame the inclusions alone, especially the sulphide inclusions in mild steels. The writer has made numerous studies of inclusions in mild and other steels and has come to the conclusion that the non-metallic inclusions play only a minor part in the

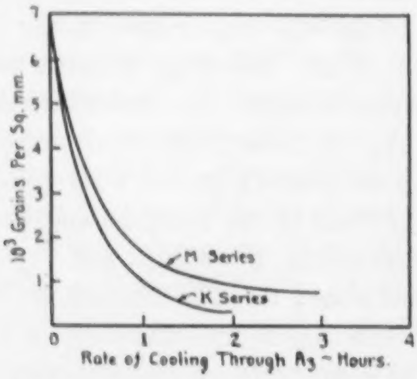


Fig. 4—Curves Showing Grain-Growth of Ferrite Versus Rate of Cooling.

recrystallization of iron and steel. The steel under investigation was found to be particularly clean.

The fifth generalization (e) is borne out by the fact that when K-2 was later annealed at 932 degrees Fahr. (500 degrees Cent.) for 10 hours, the number of grains was reduced to about 800 per square millimeter. This rate of coarsening is fully in accord with the results obtained by others. Other samples from K-2 annealed at 1112 degrees Fahr. (600 degrees Cent.) showed even better grain-growth.

The writer is aware that the last generalization (f) is open to serious criticism in many respects, because we really know very little regarding the actual mechanism of the formation of eutectics and eutectoids, especially the lamellar variety. We are all acquainted with the "intermittent" theory of Professor Howe and the "instantaneous" theory of Vogel. It is outside the scope of this paper to enter into a lengthy discussion of the formation of eutectics, and we shall confine ourselves to a brief discussion of the formation of lamellar pearlite in steel. We know that in a slowly cooled steel containing more than 0.05 per cent carbon, theoretically we may expect lamellar pearlite in the structure. We know that pearlite is a mechanical mixture of Fe_3C and ferrite

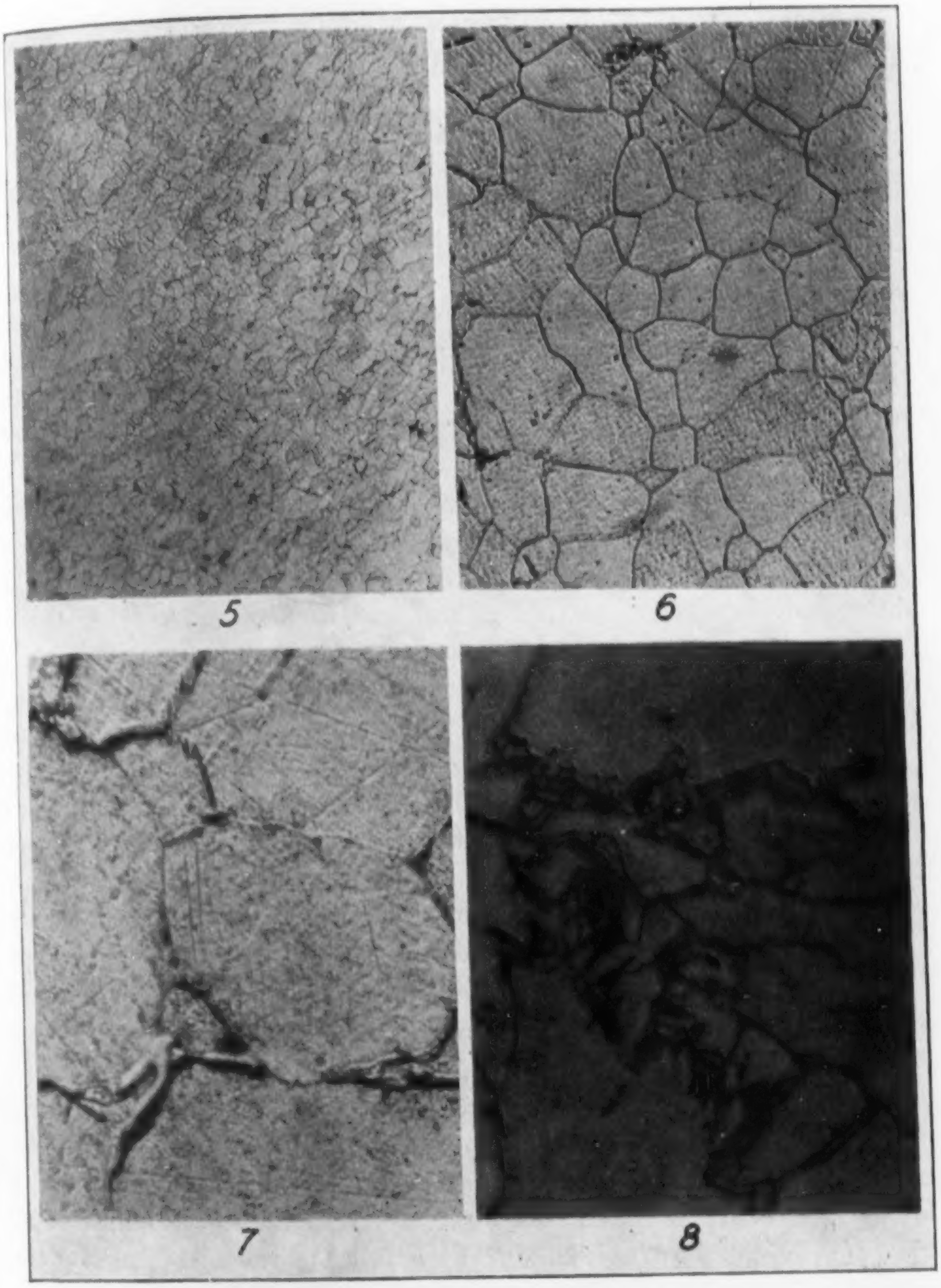


Fig. 5—Photomicrograph Showing Typical Structure of Mild Carbon Steel Strips. 100 x. Fig. 6—Same Structure as in Fig. 5, but at 500 x. Fig. 7—Same Structure as in Fig. 5, but at 1250 x (conical illumination). Fig. 8—Same Structure as in Fig. 5, but at Another Spot. 1250 x.

in a fixed ratio, which is only attained when this mixture assumes a lamellar structure. Professor Sauveur also expresses this view.

Hence, sorbitic pearlite, divorced pearlite, granular pearlite, etc., are misnomers. Heat treatment at A_1 alters the physical and chemical structure of pearlite. If the cooling through A_1 is very rapid, we obtain sorbitic pearlite, so called; on the other hand, if the cooling through A_1 is very slow, we may obtain divorced pearlite or even granular pearlite.

When a steel is heated for some time to any temperature above A_1—although a higher temperature is more desirable—and then quenched in water, we may obtain different quenching products, from austenite in which carbon is dissolved in gamma iron and martensite in which carbon is held in metastable solution in ferrite, to sorbite which is a carbide dispersoid irresolvable under the highest magnification. Nearly all are now agreed that these products of quenching are colloidal in physical structure and chemical behaviour. When a quenched steel is heated to some temperature above A_1, when the colloidal carbide may be brought into solution in gamma iron again, and then cooled comparatively slowly, we may obtain lamellar pearlite[15] as originally. When not sufficient time is given to dissolve completely the colloidal carbide, we only obtain sorbitic pearlite upon subsequent cooling. In the steel under investigation, the writer was unable to produce any lamellar pearlite by heat treatment. The hypothesis of the existence of the carbide in a colloidal state is thus inferentially confirmed by this observation. In other words, the colloidal carbide persistently refused to go into actual solution in the gamma iron, so that even with the most prolonged heat treatment and with favorable condition for the formation of a lamellar structure, the pearlite observed was in a dispersoid form known as sorbitic pearlite.

We know that the presence of a minute amount of sodium in an Al-Si alloy not only changes the eutectic ratio of the system from 11 to 13 per cent silicon, but also inhibits the formation of a lamellar structure. Jeffries'[16] explanation of colloidal particles of Na mechanically interfering with the crystallization of the eutectic is not very satisfactory. In colloidal chemistry we have many instances of the inhibitory influence of a colloidal additional

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[15](d) According to Colonel Belaiew (Journal Iron Steel Institute, No. 1, 1922, page 201) the lamellae or scales will lodge themselves, as is usually the case of secondary deposits, parallel to the crystallographic planes of the crystalline mass of the grains.

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[16]Jeffries and Archer, The Science of Metals, p. 324 and p. 344.

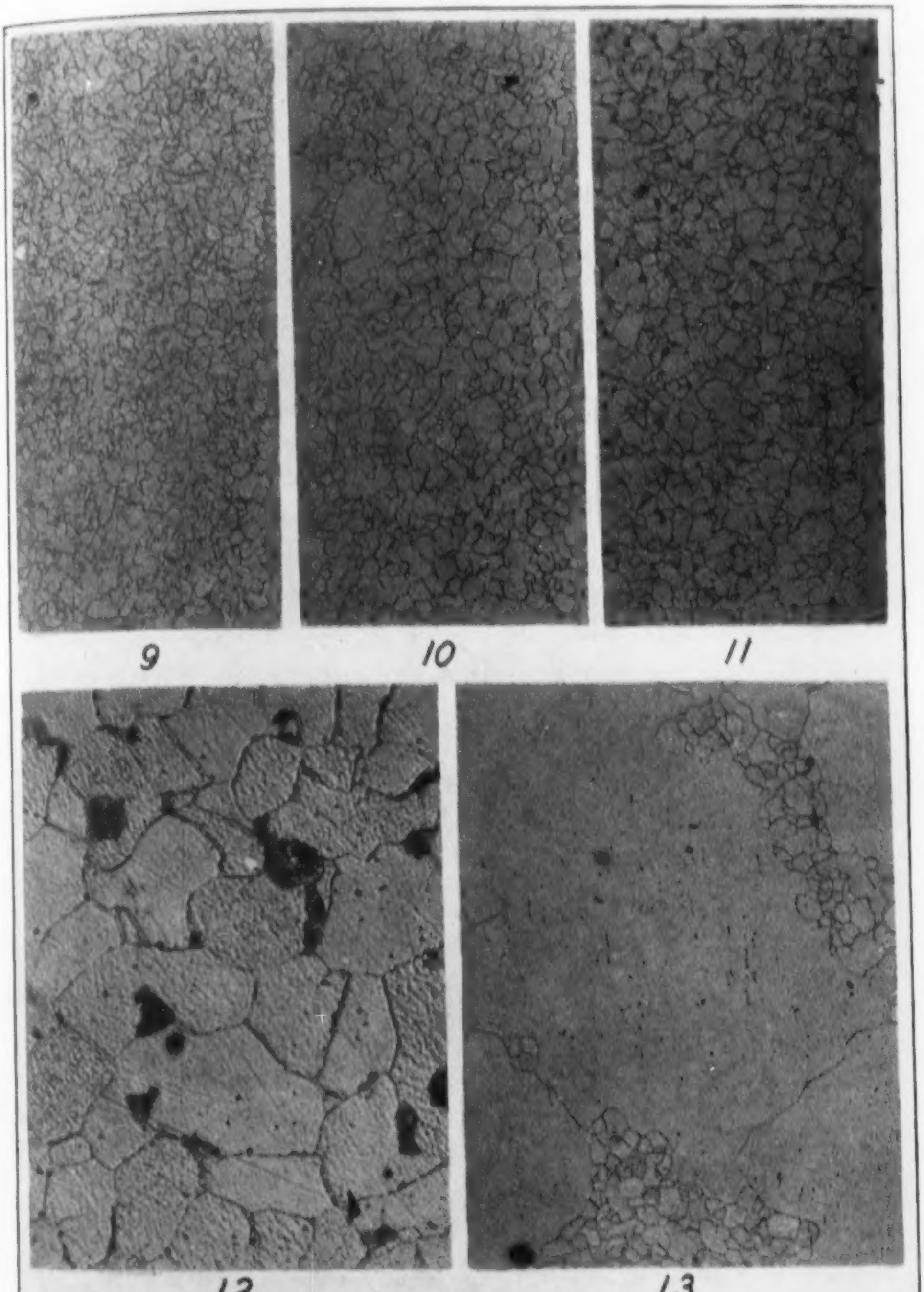

Fig. 9—Photomicrographs Showing Typical Equilibrium Structure of Samples Annealed at 1110 degrees Fahr. (600 degrees Cent.) 100 x. Fig. 10—Typical Equilibrium Structure of Samples Annealed at 1290 degrees Fahr. (700 degrees Cent.) 100 x. Fig. 11—Typical Equilibrium Structure of Samples Annealed at 1470 degrees Fahr. (800 degrees Cent.) 100 x. Fig. 12—Same Structure as in Fig. 7, but at 500 x. Fig. 13—Differential Grain Growth Due to Decarburization of Sample Annealed at 1290 degrees Fahr. (700 degrees Cent.) 100 x.

agent, such as, gelatine, glue, etc. The impurities in mild steels, though negligible in their effect in steels containing sufficient carbon (say, 0.30 per cent), perhaps play an important role inhibiting normal recrystallization at A_1.

Germination

We are familiar with the work of Stead, Sauveur, Chappell, and Charpy on the effect of a so-called critical strain upon germination in low-carbon steels. According to Sauveur, germination after local work followed by annealing below A_1 is confined to steels containing between 0.04 and 0.12 per cent carbon. The writer performed four series of experiments to study the germination in the steel under investigation. On each sample, Brinell indentations were made sufficiently far apart to allow the strain to be completely localized. As shown in the table below, the indentations were made at 500, 1000, 2000, and 3000 kilogram loads. In Series B and D, additional samples were provided which were annealed for 3 hours instead of 1 hour.

Series	Load	Temperature	Results
A	500 kg.	1200 degrees Fahr.	Slight germination.
	1000 kg.	(650 degrees Cent.)	Excellent germination.
	2000 kg.		Grain-growth but no germination.
	3000 kg.		Grain-growth but no germination.
B*	500 kg.	1365 degrees Fahr.	Identically the same results as those
	1000 kg.	(740 degrees Cent.)	obtained in Series A.
	2000 kg.		
	3000 kg.		
C	500 kg.	1562 degrees Fahr.	Slight grain-growth, but no germ.
	1000 kg.	(850 degrees Cent.)	Slight grain-growth, but no germ.
	2000 kg.		Very slight germination.
	3000 kg.		Very slight germination.
D**	500 kg.	1796 degrees Fahr.	No grain-growth nor germination in
	1000 kg.	(980 degrees Cent.)	this series.
	2000 kg.		
	3000 kg.		

*Another sample, (B-2), held for 3 hours at same temperature showed merely more grain-growth and germination. The 2,000 kg. indentation showed slight germination.

**Another sample, (D-2), held for 3 hours at same temperature showed merely some grain-growth, but no germination.

We can understand why no germination has taken place in Series D, but the absence of germination in Series C cannot be easily explained. Out of curiosity, the writer cut off a small piece

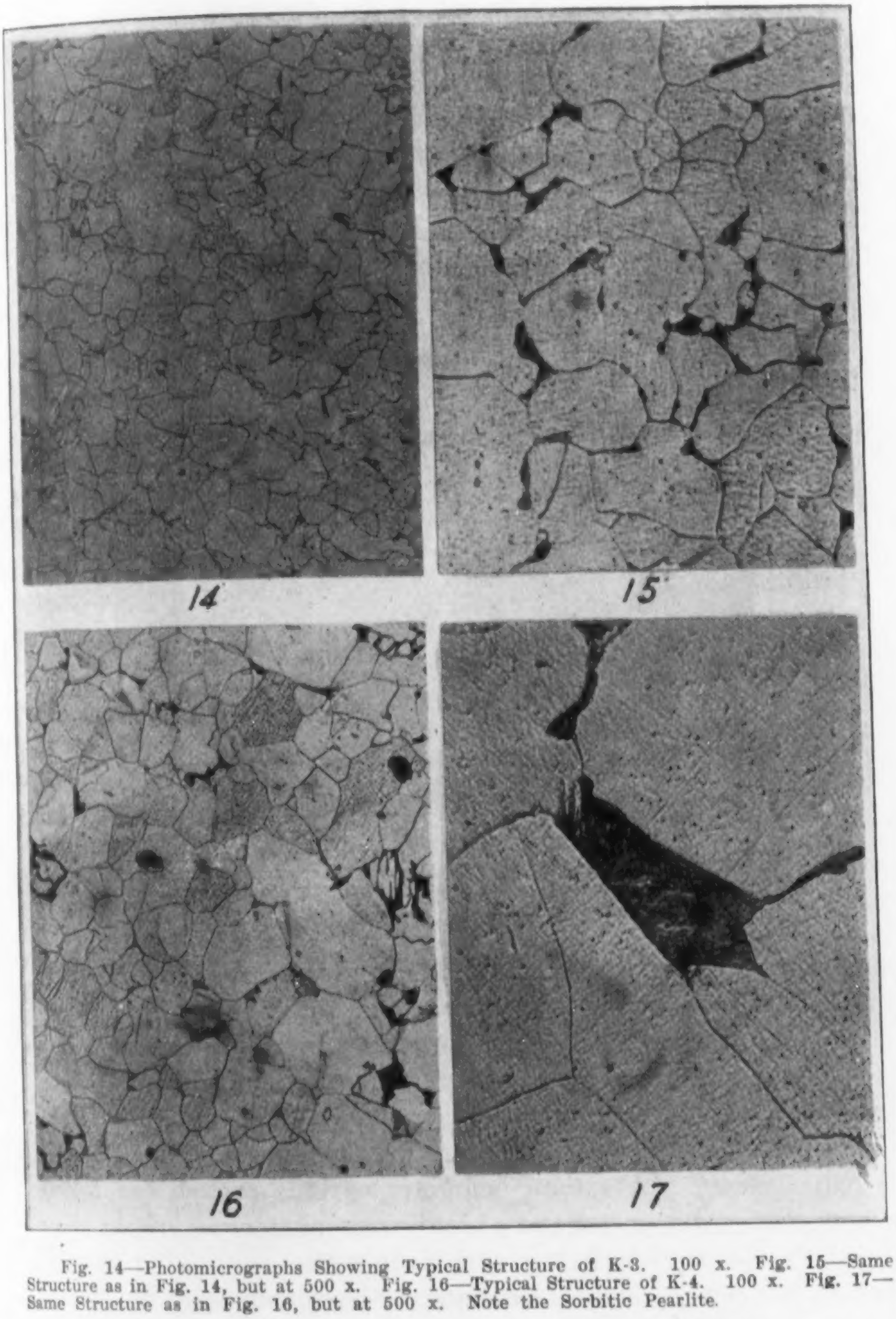

Fig. 14—Photomicrographs Showing Typical Structure of K-3. 100 x. Fig. 15—Same Structure as in Fig. 14, but at 500 x. Fig. 16—Typical Structure of K-4. 100 x. Fig. 17—Same Structure as in Fig. 16, but at 500 x. Note the Sorbitic Pearlite.

from K-3 as originally treated (see above), normalized it, and then strained in the same manner as in the other series. The sample

was normalized in order to refine the structure, as deformation of large grains followed by annealing results in refinement rather than in germination (Portevin). It was discovered that no germination occurs in the sample. The experiment was repeated with samples from the other specimens in the K and the M series and the same results were obtained. From this observation, the

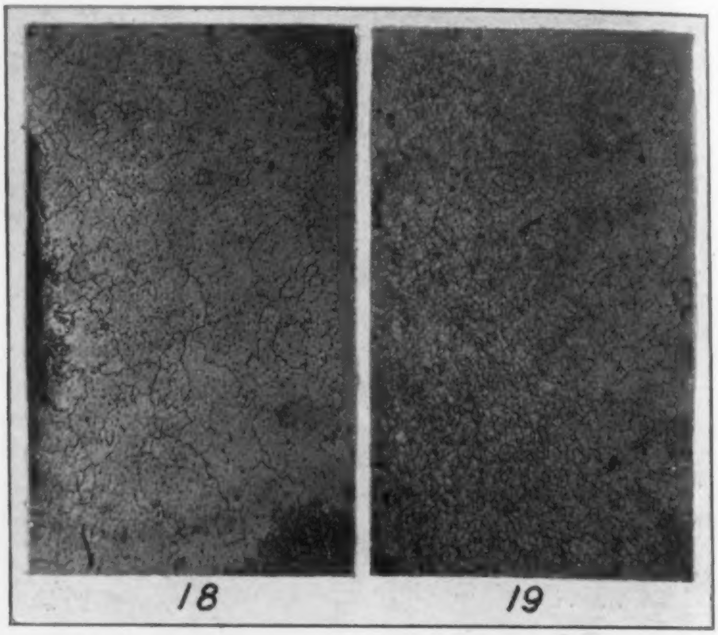

Fig. 18—Photomicrograph Showing Germination. B Series with 1000 Kilogram Load. 23 x. Fig. 19—Photomicrograph of Specimen K-2 Given the Same Treatment as in Fig. 18. Note Absence of Germination. 23 x.

writer believes that germination due to strain followed by annealing below A_1 is in some way connected with the presence of the boundary carbide film. With very mild steels containing up to 0.04 per cent carbon, we have here and there only patches of the boundary carbide film; on the other hand, steels containing much more than 0.12 per cent carbon are perhaps more likely to possess pearlite grains, rather than boundary carbide around the ferrite grains. One finds in Osmond's book[17] some photomicrographs showing the presence of boundary carbide in a steel containing as much as 0.14 per cent carbon. The writer believes that upon quick cooling through the critical range from a high temperature, boundary carbide may be found in steels containing as high as 0.18 per cent

[17]Microscopic Analysis of Metals, p. 204 et seq.

carbon, and in such an event we should be able to produce germination. The writer hopes some one that has the facilities may take up the study of this particular problem, which seems to him to be bound up with the delta transformation.

The writer knows that this paper presents a somewhat unorthodox view regarding the behavior of carbide, its structure and distribution, and its influence on the growth of ferrite. He feels, nonetheless, that whenever he had indulged in speculation it has been based on inferences from observations and experiments and on analogies from other physico-chemical researches. The correlating of various apparently unrelated series of observations necessitates some speculation. We shall make no progress if we are wanting in courage to speculate. We have no right to believe that the influence of the carbide on the ferrite is the same, whether it is distributed as boundary carbide film, or situated in the re-entrant angles of the ferrite grains. The present writer is also aware that he has no absolute right, in the absence of complete evidence, to claim that the boundary phase is a colloidal suspensoid containing the carbide, but since such a conception supplies him with answers to so many contradictory questions, he has been naturally led to champion it. He is only too well aware that many points presented in this paper need to be more carefully studied and more fully verified, and it is his intention to continue these studies in the near future. He also hopes that some of the interesting observations recorded in this paper may provoke other investigators to work on the problems suggested. Mr. John Gat is perhaps on the right path in postulating the existence of some ternary eutectoid, such as Fe-C-O, which is supposed to be comparatively stable. The writer is concerned not so much with the chemical composition of the boundary phase, but much more with its physical structure. He firmly believes that a colloidal suspensoid exists in the intercrystalline boundary in which the carbide is dispersed, and, even though his proof is not yet entirely complete, he feels that sufficient evidence has been gathered to warrant a public expression on the subject.

Acknowledgment

Although most of the material in this paper is taken from a report prepared by the writer in September, 1926, while he was a

(Continued on Page 688)

ON THE PROPERTIES OF STEELS

By James E. Howard

Abstract

The author of this paper discusses the various physical properties of steel and their behavior under different conditions. An example is that of elongation in the tensile test, which means only that displayed under the conditions of a particular test, it has a range in steels from zero upward.

Some of the points discussed are Poisson's ratio, Hooke's law, elastic limit, elongation and contraction of area, modulus of elasticity, coefficients of expansion. From this discussion the author shows the uncertainty of placing reliance upon an individual test of one type at one temperature.

The inflence of some of these properties on steel rails is selected as an example and discussed at some length.

A RECONSIDERATION of the physical properties of steels is at times useful in judging their behavior under the varying conditions which are experienced in service. Since the principal purpose for which steels are used is to endure loads or stresses of some kind attention is necessarily directed to that branch of the subject which deals with stresses and strains. The ability of steels to endure stresses is a fundamental requirement. It is convenient at times to consider the strains involved, representing the deformations, rather than the stresses which cause them. Still some numerical measure of the forces to be resisted is commonly necessary for the clear understanding of a given case.

Knowledge of the fitness of steels to endure the strains of service is best acquired by direct methods. Nevertheless, assistance is derived from indirect methods, while there are problems bearing upon which only indirect methods are applicable.

Many useful combinations of physical properties are attained by regulating the chemical constituents; others the results of heat or mechanical treatment, referring now to the primitive proper-

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A paper presented before the New York Chapter of the Society. The author, James E. Howard, is Engineer and Physicist for the Bureau of Safety, Interstate Commerce Commission, Washington, D. C.

ties imparted to the steels. It does not follow, however, that durability of steels when exposed to service conditions will bear a direct relation to their primitive properties regardless of the manner in which those properties are acquired. In general, high physical properties in one direction are acquired at the expense of those in other directions. Some methods of treatment even introduce elements of danger to the integrity of the steel. A review of the properties of steels, and their behavior under different circumstances is covered in this paper.

In applying a straining force to a piece of steel the first feature which comes to notice is its elastic extension or compression; that is, its modulus of elasticity, the normal value for which, in round numbers, is 30,000,000. So persistent is this value, under ordinary conditions, that a measure of the deformation under tension or compression is equivalent to a measure of the load which caused it. The utility of strain gage measurements depends upon this principle.

In a carefully conducted tensile test a concomitant change in lateral dimensions will be noted, a relation which is expressed by Poisson's ratio, commonly taken at ¼ of the direct strain. The writer's determination of this value was 1 over 3.55. From this ratio it is seen that the volume of steel does not remain constant when stressed but increases in volume. This circumstance affords opportunity for speculation upon the molecular disturbance when the steel is strained, and possible changed relations of the microconstituents which attend changes in the density of the metal.

Within limits, the relations between stresses and strains conform to Hook's law; a fixed proportionality being maintained between stress and strain. This fixed relation is disturbed by loads which cause permanent sets, after which in the early stages of loading as before, regular increments of stress cause progessively increasing strains. This result shows that a change in the value of the modulus of elasticity took place. After the lapse of a few days there is a recovery and the stress-strain curve again takes a rectilinear course. Herein is noted a change in the physics of the metal, the result of an overstraining force, temporary, but fundamental.

Loads above the elastic limit cause permanent sets which increase as the tensile strength of the steel is approached. Some steels display a jog in the stress-strain curve soon after rapid ex-

tension sets in, a period within which the steel stretches under a diminished load. An unstable state of the steel is manifested at this period. At higher temperatures similar periods of relaxation and rigidity alternately follow each other.

Puddled irons have shown this peculiarity in a high degree. At atmospheric temperatures when the overstraining force is intermittent the metal acquires periods of rigidity in successive stages, stress-strain curve taking a denticular course. Interrupting the straining force just prior to reaching the tensile strength of the iron a degree of strength is acquired, under suspension of the stress, reaching considerably above normal. Retests of certain puddled irons after the lapse of several years have shown a gain in tensile strength many thousand pounds per square inch above original values.

At this time experience with lead cylinders will be mentioned. A lead cylinder taken longitudinally from a pig will assume an elliptical shape when compressed, lateral flow taking place almost entirely in the direction of the major axes of the crystals. If the upsetting is interrupted, and resumed a few hours later, radial flow will then take place in all directions restoring the specimen to one of cylindrical cross section. Respect for lead as a metal is much enhanced by such a manifestation, nothing like it having been observed in steels. Such clues are worth following.

Returning to the discussion of steels, the phenomenon of contraction of area is next noted, then tensile strength. As the ultimate strength is approached local contraction of area sets in. The gross load falls but the unit stress on the reduced section continues to rise until actual separation of the metal occurs.

The values of elastic limit, elongation, contraction of area and tensile strength are not fixed in any grade of steel. They are one thing at one temperature and another thing at another temperature, and all are subject to profound modifications by means of heat or mechanical treatment. Tensile strength reduces to zero value at high temperatures when plastic resistance only prevails. As the results of mechanical treatment tensile strength attains a maximum value in hard drawn music wire, the maximum value being more than 460,000 pounds per square inch. It has a certain value at atmospheric temperatures, a higher value at a blue heat, at which time overstraining enhances the value when again lowered to

atmospheric temperature. From a low sag at the temperature of boiling water the curve of tensile strength rises until the steel falls to the temperature of liquid air.

The elastic limits of steel are also subject to variations with changes of temperature. As nearly as can be judged elastic limit steadily decreases with rise of temperature. Its greatest divergence from tensile strength appears to be when at a blue heat. It is believed to coincide with tensile strength at liquid air temperature, its maximum value, and again coincide with tensile strength when each are reduced to zero values at plastic temperatures.

Elongation and contraction of area necessarily reduce to zero value at low temperatures when tensile strength and elastic limit coincide. At high temperatures steel draws down almost to a point, a value of over 98 per cent contraction of area having been recorded. A sag in the curve shows diminished contraction of area in the region of 400 to 600 degrees Fahr. This circumstance is probably responsible for the impression which has prevailed that steel is brittle at a blue heat. Maximum elongation occurs somewhere in the zone of temperature between atmospheric and a blue heat.

The values just described are those which steels display in tensile tests, when the resistance to elongation is confined to the metal itself. Rolling, swaging and wire drawing operations yield different results, when done either hot or cold. Other modifications and features remain to be described. In hot-finished steel bars an equality in elastic limits commonly exists. That is, the elastic limits in tension and compression have substantially the same value. Overstraining the steel in one direction impairs the value of the elastic limit in the opposite direction. The algebraic range of the two is greatest in the first instance.

Alternate stresses of tension and compression, even below the primitive elastic limits, as such values are commonly defined, when repeated eventually rupture the steel. In such cases there is little or no display of elongation or contraction of area. The writer believes that he established the fact that destruction of ability to permanently elongate is a phase through which the steel passes preceding the actual rupture of any fiber. If such is the case annealing would be expected to efface some of the effects of the

repeated stresses. Annealing has been found to restore toughness to cold-worked, embrittled steel.

The moduli of elasticity of steels are lowered in value by rise of temperature. Reductions of several thousand units per square inch have been noted in tests made at higher temperatures.

Respecting coefficients of expansion, the percentage of carbon in the steel appears to have a controlling influence on its rate of expansion which varies inversely with the carbon content. That is, high carbon steels and cast irons display the lower values, low carbon steels and wrought iron display the higher coefficients.

Coefficients of expansion do not appear to have fixed values, the higher carbon steels notably showing the result of modifying influences. Such bars when hardened, (i. e., heated and quenched in water) display values higher even than those normal to low carbon steels or wrought irons. A further peculiarity has been noticed. When first heating a hardened bar the dilatation incident to rise of temperature is counteracted in part by a simultaneous contractile effect, permanently shortening the bar. This effect takes place upon exposure to moderate temperatures far below the recalescent zone. Evidently a struggle goes on in hardened steel which a moderate rise in temperature in some degree relieves. Herein is evidence of the presence of internal strains in steels caused by heating and quenching which occasionally attain such a degree of magnitude that spontaneous rupture takes place. Internal strains are introduced by less drastic treatment than sudden quenching in energetic cooling mediums. Cooling steels in water, oil or air blast each introduce internal strains which may reach a degree of magnitude coincident with the elastic limit of the steel.

Cooling strains are difficult to avoid. They are practically unavoidable, in the commercial production of structural shapes. Internal strains in 12 inch steel channels have been measured equivalent to 10,000 pounds per square inch tension and in the same member 13,000 pounds per square inch compression, a range of 23,000 pounds per square inch in all. The futility of attempting to establish a formula for long columns on a mathematical basis, ratio of length to radius of gyration, under such circumstances is quite obvious.

Some general rules apply to the introduction of cooling strains, but each structural member may be expected to show a difference

in the location and relations of the internal strains of tension and compression respectively. Cooling will proceed faster from one surface than another in the ordinary handling of steel members, corners faster than flat faces, and thin flanges faster than thick ones. Cooling strains thus are practically unavoidable. Their presence in some members may be ignored, in others they must be reckoned with.

Summarizing, in these remarks upon the properties of steels we note that the value of the modulus of elasticity is a fairly definite quantity, if not disturbed by overstrains or by wide changes in temperature; that the elastic limits in tension or compression are fixed values in a given steel only under some circumstances; that elongation in the tensile test means only that displayed under that test, that it has a range in steels from zero upward, that contraction of area ranges from zero to nearly 100 per cent; that tensile strength has a fairly fixed value according to composition, but not according to temperature or treatment, covering a range from zero to above 460,000 pounds per square inch; that elongation and contraction of area reduce to zero simultaneously when elastic limit and tensile strength reach their maxima; that elongation stands a little apart by itself in respect to the display of its maximum value; but under certain conditions of loading it reduces to zero value at atmospheric temperatures in all steels; that coefficients of expansion may be varied at will by suitable treatment; it has also been demonstrated that the elastic extension of one inch of steel limited to two one-thousandths of an inch in the tensile test is capable of displaying an aggregate extension of more than a mile under regulated alternate stresses; that under cubic compression no finite load has any effect on the physical properties of steels; that under cubic tension steel is shattered without display of toughness; that the introduction of internal strains is practically unavoidable; that such strains in some cases are negligible, in other cases internal strains cause spontaneous rupture of the metal.

These properties are presented in different values and combinations. It is a wise person who can tell what combinations best meet given contingencies. Reliance placed upon an individual test of one type at one temperature, a tensile test or perchance a

drop test, puts us into a group of people resembling a one dimension community.

Relation to Steel Rails

Reference will be made to the influence of some of these properties on steel rails, selected as a prominent example in the use of steel. When a rail emerges from the last pass of the rail mill it is given a sweep by the cambering device to compensate for later changes in temperature. The cambering is done in the plane of the web, and has to do therefore with the relations between the head and the base of the rail. Balanced sections, so-called, are sometimes used, but internal strains are not thereby avoided. The flanges of the base cool relatively quite rapidly, particularly so in the case of thin flanged rails. They acquire a final state of internal compression of higher degree than other parts of the rail. It is customary to find a state of tension at the junction of the web and the base, and also under the head. The peripheral surface of the head, for the most part, acquires a state of compression, the interior of the head a state of tension. Except in the flanges the strains due to normal rate of cooling are not great. Accelerated cooling by air, oil or water quenching intensifies the internal strains in all parts of the cross section of the rail.

Gagging disturbs the arrangement of the internal strains, even reversing their directions. Strains are not taken out by cold bending, but modified in position and intensity. Unless disturbed by gagging those in the base commonly remain without material change. Cooling strains in the head are less in magnitude than those of the base; in the heavier sections notably less.

It is quite another matter when the rails reach the track. Internal strains are at once introduced by the cold rolling action of the wheels. The intense impinging pressures affect the zone of metal next the running surface. The relative narrowness of the head affords opportunity for some lateral relief to the effects of the wheel pressures, longitudinally internal strains accumulate and reach high values. Internal strains of compression are acquired in the upper zone of the head, which are balanced by strains of tension in the interior. Internal strains in the central core of the head explain the cause of the development of transverse fissures.

Exhaustion of toughness by the cold rolling action of the

wheels tends to cause head checks, that is, progressive cracks at the corner of the head, most prevalent on the gage side. Successive hammerings of the web of the rail against the shanks of the track bolts destroy the toughness of the metal and lead to bolt hole fractures.

Split heads, horizontal and vertical, result from the impinging pressures omitting reference to transverse fissures. Opportunity for starting a split head depends upon the internal strains encountering a line of weakness in the steel, such as presented by a slag streak. Cooling strains seem adequate to originate a split head fracture, but its extension would depend upon the action of the wheel pressures.

The limiting span of a bridge is reached when the bridge can no longer sustain its own weight. The limit of wheel pressures is reached when no grade of steel can be found that will endure it. That is the crux of the rail problem. It is neither girder strength nor abrasive resistance, but impinging pressures of intensity and volume that control.

A railroad track, obviously, is not the best place available in the study of the physics of materials. Nor is it a place where the finer distinctions may be made in the definition of those properties of steels which possess or at least display differences in durability. According to track reports different rollings and also different heats of the same rolling not infrequently display different degrees of endurance. Early fractures are reported in new rails. Granting that track conditions are variable and not definable with extreme accuracy, careful laboratory examinations of rails, exceptional in their behavior, should throw light upon the cause of their fractures whether due to service conditions or to the steel itself. The users and possessors of the rails, those most familiar with their behavior, are from position best situated to conduct inquiries into the subject of durability, substituting exact information for conjecture.

Such destructive incidents as wheel burning do not involve polemical questions. Intense local heating overstrains the vicinity by compression which reverses to a state of tension when the steel cools, and originates hair line cracks. Possibly there is not a mile of track which does not furnish an example of a rail damaged by

(Continued on Page 650)

COMPARISONS OF IMPACT AND SLOW BEND TESTS OF HIGH SPEED STEEL

By R. K. Barry

Abstract

In a previous paper on the influence of tempering temperature on the hardness and toughness of high speed steels the author has given the results of his tests. This paper gives the results of additional tests carried out by two other investigators in collaboration with the author.

The results obtained show that high speed steel is harder after tempering at 1100 degrees Fahr. than when tempered at 900 degrees Fahr., it will therefore have a higher tensile strength and higher transverse breaking strength with maximum deflection which would tend to increase the brittleness and to decrease the deflection under slow bend. High speed steel tempered at 900 degrees Fahr. is tougher or more ductile than when tempered at 1100 degrees Fahr., which was indicated by impact test.

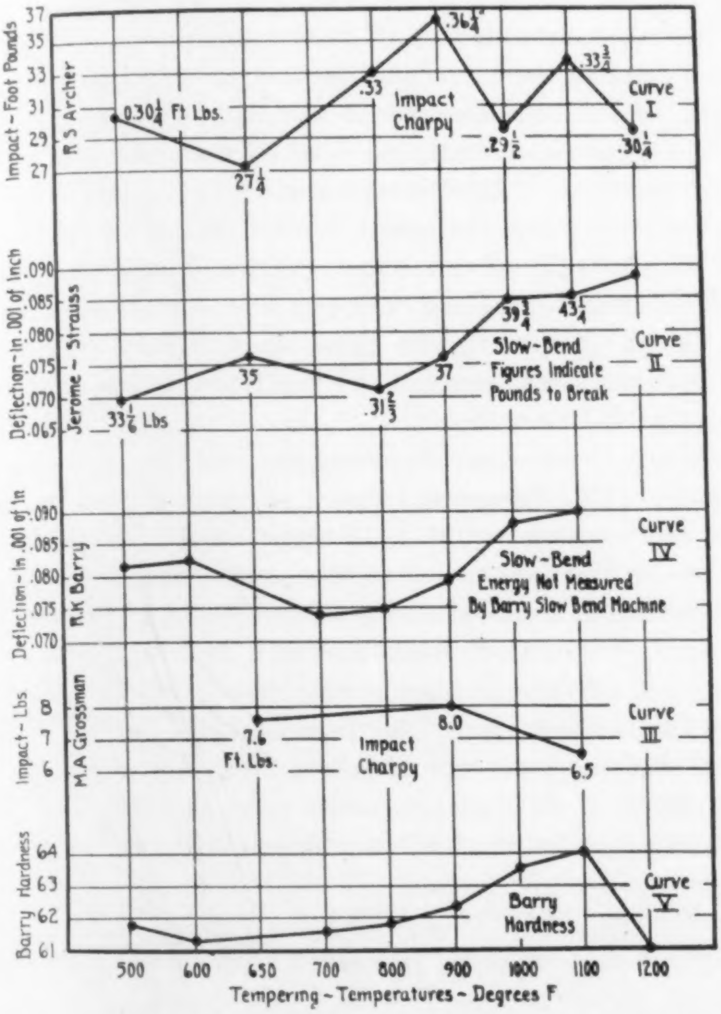
THE influence of various tempering temperatures on the hardness and toughness of high speed steel has been shown in a previous paper (TRANSACTIONS 1926).[1] In brief, maximum penetration hardness with the highest deflection under slow bend were obtained after tempering at 1095 degrees Fahr. According to Grossmann, the highest impact values occur after tempering at 890 degrees Fahr. for all tempering temperatures up to and including 1100 degrees Fahr. It was arranged that additional tests be made in collaboration with Jerome Strauss and R. S. Archer because of their interest in the subject.

Three sets of similar test specimens were prepared, one for Archer and one for Strauss, the third set being retained by the author for the purpose of checking his previous work. The method followed in preparing the material was exactly the same as that already described,[1] with one difference, namely, the material for

[1]TRANSACTIONS, American Society for Steel Treating, Aug., 1926, pp. 257 to 259.

A paper presented before the Chicago Convention of the Society, September, 1926. The author, Robert K. Barry, is in charge of heat treating The Barry Company, Muscatine, Iowa. Revised manuscript received August 17, 1927.

the present tests was pack annealed to relieve strains and increase its physical uniformity. The material for the former and the present work was selected from the same lot of drill rod.



Curves Showing the Results of the Different Investigators. Curves I, II, IV, V, Steel Heated to 2310 degrees Fahr. Quenched in Oil. Curve III Steel Heated to 2250 degrees Fahr. Maximum Fiber Stress Curve Similar to II and IV. Specimen for Curve III 0.375 inch square x 2.17 inches long.

Deflection Readings for Curves II and IV Taken at Moment of Rupture.

Curves I, II, IV, V. Specimens Preheated to 1600 degrees Fahr., High Heat 2310 degrees Fahr., Quenched in Oil.

Each set consisted of seven bundles with four pieces two inches in length to each bundle. The material used was cold drawn and ground high speed drill rod, 0.072 inches diameter, of 18 per cent tungsten steel. Each set of seven bundles was hardened separately

with the assistance of a timer, the heating for hardening was done on thin trays supported at the ends to permit heat circulation. The trays were placed in close proximity to a platinum platinum-rhodium couple, and heated to 2310 degrees Fahr., then quenched in oil. Each set consisted of 28 individual pieces, which was permissible because of the extremely small cross section of the material. Hardening the seven bundles at one time resulted in uniform hardening, a condition impossible when standard test pieces are separately hardened. After tempering, each bundle contained four pieces which had been uniformly hardened and tempered for the purpose of determining the effect of that particular heat treatment. Reference to the chart shows five curves as follows: (1) Impact Values (Archer); (2) Slow Bend Values (Strauss); (3) Impact Values (Grossmann); (4) Slow Bend Values (Barry); (5) Hardness Curve (Barry).

The seven bundles, or 28 pieces, for sets No. 1, 2, and 4 were all hardened at 2310 degrees Fahr. and tempered, as shown. The value for any one temper is the average of the values determined for each one of the four pieces in the bundle used for that temper.

As evidence of the consistency of slow bend tests when measuring uniformly treated file hard material, readings being taken at the moment of rupture, it may be mentioned that the variations in deflection for the four pieces tempered at 500 degrees Fahr. were only 0.005 inches, while the breaking load required for each of the four pieces in the bundle varied only ½ pound. Variations for the groups tempered at other temperatures are as follows:

Tempering Temperature, Degrees Fahr.	Variation in Deflection in Inches	Variation in Load in Pounds
650	.001	½
800	.008	5½
900	.004	2½
1000	.005	1½
1200	.004	1½

The variations in the impact energy required to break each one of the four pieces in the several bundles are as follows:

Tempering Temperature, Degrees Fahr.	Variation in Energy in Ft. Lbs.
500	17
650	11
800	7
900	31
1000	4
1100	25
1200	17

The degree of consistency shown by the individual specimens

of each group is about what is usually obtained in impact tests on file hard steel.

Summary

Archer reported the highest impact values on the four pieces from the bundle tempered at 900 degrees Fahr. which is in agreement with Grossmann, and the lowest values on the specimens from the bundle tempered at 650 degrees Fahr. Incidentally the latter temper gives minimum hardness readings for tempers up to 1100 degrees Fahr. The drop in the curve after tempering at 1000 degrees Fahr. is interesting, but not so easily explained.

Strauss reported the highest deflection values under slow bend, together with the greatest energy required to rupture for the four pieces tempered at 1100 degrees Fahr., which is in agreement with the author's results. Tempering at 1100 degrees Fahr. also produces maximum hardness for tempers up to that temperature. It may be significant that more energy (43+) was required to break the test pieces tempered at 1100 degrees Fahr. than those tempered at any other temperature. If tempering at 1100 degrees Fahr. gave high deflection with low loads, it might well be concluded that there was an absence of strength.

The machine used by Strauss for the deflection tests was a lever type of 4000 pounds capacity, recently calibrated and found to be less than ¼ pound in error in the range used. This machine is highly sensitive and very accurate. The two-inch test pieces were placed on hardened V blocks having a radius equal to that of the test specimens, the span being 1½ inches. Deflection readings were taken with a dial gage placed directly under the specimen, and having a sufficiently long hand and large graduations which made reading very positive. To insure further accuracy, two operators were used, one at the beam and one at the dial. The author's deflection curve follows quite closely the one determined by Strauss, and also the maximum fiber stress and deflection curves determined by French and Strauss. The hardness curve indicates the usual increase in hardness for properly hardened high speed steel as the tempering progresses to 1100 degrees Fahr.

The impact tests reported by Archer were made with a Charpy impact machine, equipped with a five-pound pendulum to give

sensitivity on materials of low impact value. This machine has been described in detail by E. H. Dix, Jr.[2]

CONCLUSIONS

High speed steel being harder after tempering at 1100 degrees Fahr. than when tempered at 900 degrees Fahr. will therefore have a higher tensile strength and a higher transverse breaking strength with maximum deflection when, theoretically at least, the higher temper would tend to increase the brittleness and at the same time decrease the deflection under slow bend. If we conclude then, that steel tempered at 900 degrees Fahr. is tougher or more ductile than when tempered at 1100 degrees Fahr. as has been indicated by impact tests which may measure the total amount of work done in breaking a test piece, then we could assume that the test piece tempered at 900 degrees Fahr. bends under impact through a larger angle, thus absorbing more work before rupture. The piece tempered at 1100 degrees Fahr., assuming it to be less ductile, will bend under impact through a smaller angle and thus absorb less work.

The use of small diameter high grade drill rod in conducting physical tests of the nature here described offers an inexpensive and sensitive method of accurately determining the effect of slight variations in treatment, and is believed to merit further consideration.

The author wishes to express his appreciation of the co-operation of R. S. Archer, research metallurgist, Aluminum Co. of America, and Jerome Strauss, materials engineer, U. S. Naval Gun Factory, for the test data shown and their interest in the work. His thanks are also due to Marcus A. Grossmann, metallurgist, Central Alloy Steel Corp., for his interest in the preparation of this paper.

[2] "Charpy Impact Test as Applied to Aluminum Alloys," *Transactions*, American Institute of Mining and Metallurgical Engineers, 1920.

TESTING AUTOMOBILE BODY SHEET STEEL

By J. Winlock and G. L. Kelley

Abstract

There is no generally accepted method for testing the class of sheet steel which is used in the manufacture of automobile bodies. If such a test could be devised, it would help the manufacturer to produce steel having the physical properties necessary to its use in making stampings of varying difficulty. Sheet steel used in automobile bodies must meet severe requirements as to both surface and ductility. Much progress has been made toward the fulfillment of these conditions, but a chief obstacle to the development of a suitable test lies in the lack of uniformity in the properties of the material. A reasonably small number of sheets taken for test does not always adequately represent the lot. In this paper, we shall discuss briefly the conditions governing the making of stampings and show the results obtained in tests in which the physical properties of the steel are shown in their relation to its performance on the die. The authors do not consider the problem solved, but some interest will attach to the fact that our findings differ somewhat from those of other experimenters in this field.

IT must be borne in mind at the outset that any attempted correlation of the deep drawing properties with the physical properties of sheet steel can be undertaken and discussed only with a full realization that *the manner in which the draw is accomplished* is, within limits, of equal, if not of greater importance, to the success of the operation than the physical properties of the steel itself. For example, it is known that if the steel could be formed under conditions which would prevent local over-strain, as when such loading is produced hydraulically[1], much deeper and more complicated draws could be made, other conditions being constant. In ordinary die work, however, stampings whose design necessitates a deep draw are usually made on a die which when on the press

[1]See "Properties of Matter under High Pressure", P. W. Bridgman, *Mechanical Engineering*, Vol. 47, No. 3.

A paper presented before the ninth annual convention of the society, Detroit, September 19 to 23, 1927. The authors, J. Winlock and G. L. Kelley, are associated with The Edward G. Budd Manufacturing Company, Philadelphia. Manuscript received May 25, 1927.

exerts pressure on the blank near its periphery while a punch whose contour contains the form of the finished article draws and presses the metal into the desired shape. In such a method the conditions necessary for the maintenance of a uniform thickness throughout the operation do not exist. Here the method of applying the stress, the friction between the die and the metal, together with sharp corners and prominences in the contour of the dies cause the development of highly localized stresses which defeat the fulfillment of this condition.

Further, the amount of pressure exerted on the sheet by the blank-holder is governed by the depth and shape of the draw and the thickness of the metal. That is to say, the amount of pressure is directly proportional to the tendency of the metal to wrinkle or buckle, and this tendency is, in turn, inversely proportional to the increase in the gage of the material being formed. This observation in itself precludes the possibility of ever finding a test which will in itself indicate the deep drawing properties of the steel unless that test be correlated by empirical methods with each individual stamping. This is because the physical properties from a metallurgical point of view may be the same and yet yield different results depending upon the thickness of the metal used. Again, the properties of the metal may vary according to the depth and shape of the ultimate formation.

It has been possible, however, to show that most of the stampings that are made today and according to present methods, may be successfully produced if certain properties exhibited in test are met in the sheet. It is obvious, however, that there is a maximum ductility from a deep drawing standpoint that can be obtained in sheet steel, although the exact conditions are not yet known which yield this. When this maximum ductility can be regularly produced the manner in which the draw is accomplished must be modified, if deeper and more complicated draws than those at present become necessary.

The correlation of the physical tests with performance in the die exhibited every conceivable variation, but when carried out for a number of years and viewed statistically in the averages obtained, there was indicated a general underlying relation even though individual tests were sometimes misleading. Often only widely separated sheets differed in test values, but again differences were

detected in adjacent sheets and often, too, in different parts of the same sheet. On the other hand, it was often noted that certain lots of material would work satisfactorily on a given die while other lots tried out on the same setting of that die, with or without variation of pressure on the blank-holder, would perform either less satisfactorily or not at all. An exhaustive examination of such instances generally disclosed in the test results the reasons for the behavior of each.

To obtain samples for testing, sheets were taken only when the die was on the press and working regularly, i. e., when all or none of the stampings were breaking. The actual performance and appearance of the material was observed and recorded at the time the sample was taken. The lots which failed to work were often tried again later in the same run and on a subsequent set up. The tests were tabulated with respect to the die on which the stampings were being formed. In this way true data as to the performance was obtained and test results correlated.

Of the different methods of testing and correlation of the different properties obtained by the methods used, experience showed that the percentage elongation as obtained in the ordinary tensile test gives the most reliable indication of the deep drawing properties of sheet steel, and, further, that this property is of greatest value when obtained in directions both parallel and transverse to the direction of final rolling. Sometimes a high capacity for elongation is necessary in only one direction, but again the properties in both directions must be good.

For the tensile test, a specimen 0.750 inches wide with an 8-inch gage length, divided into eight 1-inch gage lengths was used. The percentage elongation in 8-inches was noted as well as the elongation in the 2-inch gage length which included the fracture. It is realized, of course, that the value for elongation in the 2-inch gage length obtained in this way is a little higher than if a specimen containing only a 2-inch gage length had been used. It is believed that for purposes of comparison, however, the method used is substantially correct. If the fracture occurred at the center of one of the 1-inch gage sections, an average was taken. The thickness of the test piece varied with the thickness of the sheets which in these tests ranged from 0.030 to 0.060 inches. A variation in thickness, other factors being held constant, will affect the percentage elonga-

tion, but in these tests this difference is believed to be well within the limits of experimental error. In the majority of cases, six tests were taken from each sheet; three parallel to the direction of rolling and three transverse to the direction of rolling. The average of

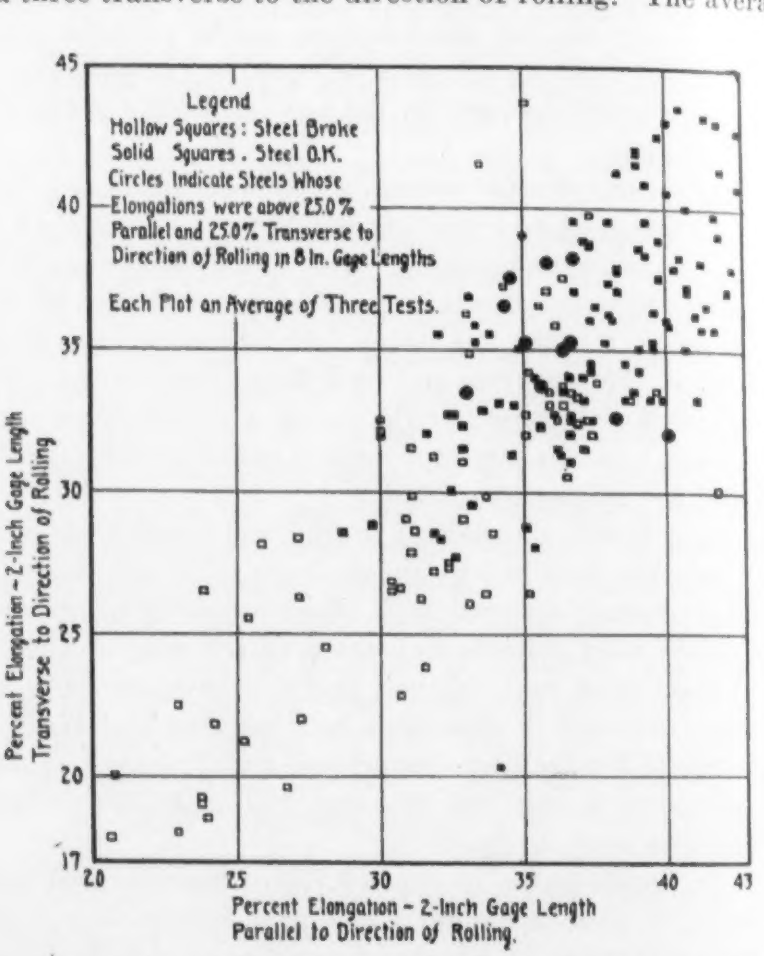


Fig. 1—Per Cent Elongation in 2-Inch Gage Length. Values for Tests Parallel and Transverse to Direction of Rolling.

the former was plotted as ordinates and the latter as abscissae. The yield point ("drop of the beam") and tensile strength were obtained in the usual way. No effort was made to obtain the reduction of area on account of the thinness of the sheets although this figure would have been of great interest.

In Fig. 1 is given the percentage elongation in 2-inch gage lengths and in Fig. 2 the corresponding percentage elongations in 8-inch gage lengths. It was found on observation of Fig. 1 that the most difficult stampings were made successfully when the mini-

mum elongation in the 2-inch gage length of test pieces taken parallel to the direction of rolling was 37.0 per cent, and when, at the same time, the elongation in test pieces taken transverse to the direction of rolling was 34.0 per cent. (As may be seen in Fig. 1 there is one exception to this, but this test is considered to be a "sport").

It was found on observation of Fig. 2 that the most difficult stampings were made successfully when the minimum elongation in

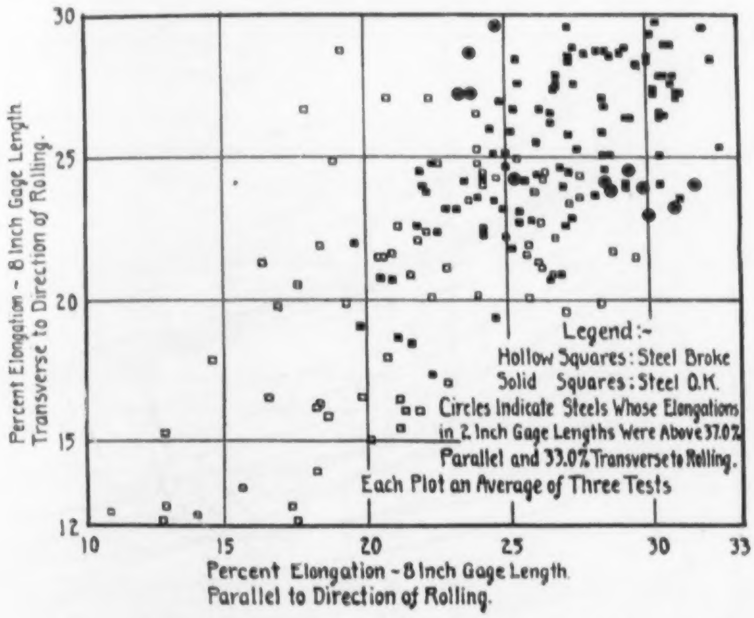


Fig. 2—Per Cent Elongation in 8-Inch Gage Length. Values for Tests Parallel and Transverse to Direction of Rolling.

the 8-inch gage length of test pieces taken parallel to the direction of rolling was 25.0 per cent, and when, at the same time, the elongation in test pieces taken transverse to the direction of rolling was 25.0 per cent.

In order to test the validity of these figures, a rough classification of the relative difficulty of the different stampings was made. It was found that those stampings which were formed successfully from steels having lower percentage elongations than those just mentioned, were those with which comparatively little difficulty is encountered. They were easy to make because they gave little difficulty.

It was also noted that steels which fulfilled these minimum

values for the 2-inch gage length were not in all cases the same steels that showed values greater than 25.0 per cent in the 8-inch gage length. At first this might seem to be due to errors in testing, but as may be seen in Fig. 3, there does not appear to be a direct and constant relationship between the percentage elongation in 2-inch and 8-inch gage lengths. In other words, the present methods of manufacture do not yield a product uniform enough to show in different sheets in the same lot physical characteristics

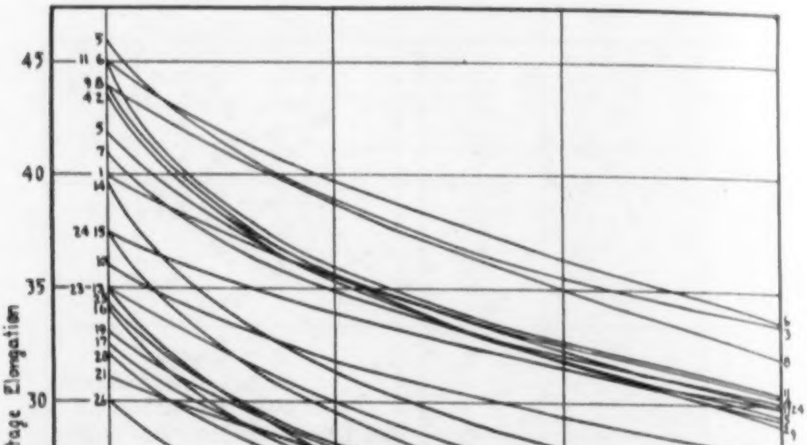


Fig. 3—Per Cent Elongation Vs. Gage Length. Values Obtained on 8-Inch Gage Length Specimens.

which are exactly alike. Fig. 3 was obtained by measuring the percentage elongation in different gage lengths on test specimens from different lots which broke at the center.

From this it would appear that there might be an advantage in using one gage length as compared to the other. That this is not borne out in these tests is shown by the fact that of the total number of steels which fulfilled either or both of the minimum qualifications for the 2-inch and 8-inch gage lengths, 83.0 per cent met the former

and 82.6 per cent met the latter. If, then, either gage length were used as an acceptance test to the exclusion of the other, approximately 17.0 per cent of the material tested would be discarded as unsatisfactory when actually this 17.0 per cent would have passed the minimum qualifying elongations in the other gage length. It would seem somewhat preferable, therefore, to use a specimen containing an 8-inch gage length and noting elongations in both gage lengths. In this way, those steels which passed either the 2-inch

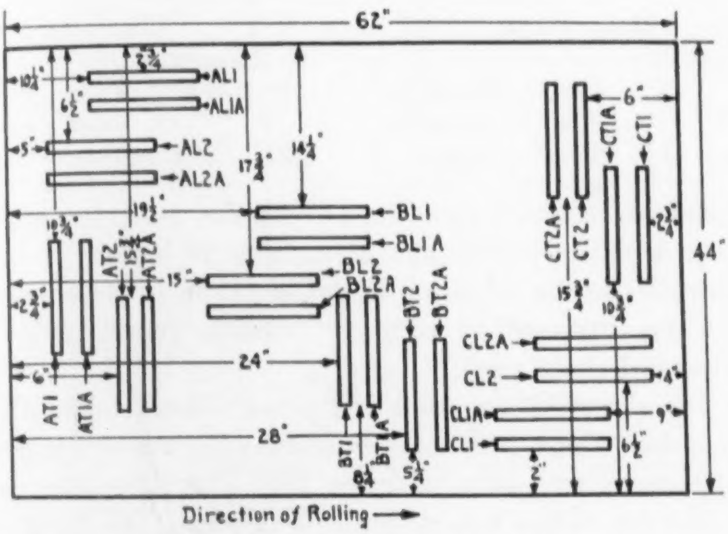


Fig. 4—Diagram Showing How Specimens Were Cut From the Sheet.

or 8-inch qualifications would be accepted and the error in rejections would be entirely removed. The design of a stamping may be in some instances such as to require that the metal be capable of considerable general stretching and again it may require a high degree of local elongation. It is probably such differences as these which cause material having a high elongation in two inches to work satisfactorily even though the elongation in eight inches is somewhat below the usual standard.

The average tensile properties of the steels which met the 2-inch gage length minimum elongations are:

Longitudinal				Transverse			
% Elongation				% Elongation			
2"	8"	Yield Point (Lbs. per Sq. In.)	Ultimate Strength (Lbs. per Sq. In.)	2"	8"	Yield Point	Ultimate Strength
40.2	27.3	26900	41400	37.3	25.3	30700	45600

The average tensile properties of the steels which met the 8-inch gage length minimum elongations are:

Longitudinal				Transverse			
% Elongation				% Elongation			
2″	8″	Yield Point	Ultimate Strength	2″	8″	Yield Point	Ultimate Strength
36.2	27.4	24700	39900	35.4	26.5	28800	45000

The average tensile properties of the steels which met the minimum elongations for both gage lengths are:

Longitudinal				Transverse			
% Elongation				% Elongation			
2″	8″	Yield Point	Ultimate Strength	2″	8″	Yield Point	Ultimate Strength
39.8	29.2	24000	40300	38.3	27.8	27800	45200

It should be noted that the yield point and ultimate strength are lower and the percentage elongation is higher in test pieces taken parallel to the direction of rolling than in those taken transverse to the direction of rolling. This is generally the case in tensile tests of sheet steel.

It was observed also that individual sheets taken from a lot which yielded a high percentage of breakage might show good test results. One or two tests will not give, therefore, the reason for failure of a lot unless one or both of the tests fall below the minimum elongations. In short, there must be uniformity within a somewhat narrow range throughout the same lot in order that tests be indicative.

As has been pointed out, the properties will sometimes vary in different parts of the same sheet. This may be caused by annealing at too low a temperature, by heating too short a time at the proper temperature, or by other factors. This is shown in the following results which show the tensile properties before and after annealing at 1150 degrees Fahr. The specimens were cut from the sheet according to the method shown in Fig. 4.

The results of the tensile tests before annealing in the laboratory were:

	Longitudinal				Transverse			
Properties At Position	% Elongation 2″	8″	Yield Point	Ultimate Strength	% Elongation 2″	8″	Yield Point	Ultimate Strength
A	31.5	15.8	32,900	41,500	24.0	16.1	34,500	41,500
B	35.0	25.0	30,900	41,900	32.0	18.7	34,500	48,900
C	28.0	20.5	34,300	49,000	31.0	20.9	32,100	48,500

The results of the tensile tests after annealing at 1150 degrees Fahr. in the laboratory were:

	Longitudinal				Transverse			
Properties	% Elongation		Yield	Ultimate	% Elongation		Yield	Ultimate
At Position	2″	8″	Point	Strength	2″	8″	Point	Strength
A	36.0	29.1	22,400	39,500	30.8	22.9	24,100	46,400
B	35.5	29.0	21,800	39,700	39.5	25.1	27,100	47,400
C	36.0	30.9	29,700	45,600	39.0	30.3	27,500	47,500

In Fig. 5 are plotted the yield points of the same steels as in

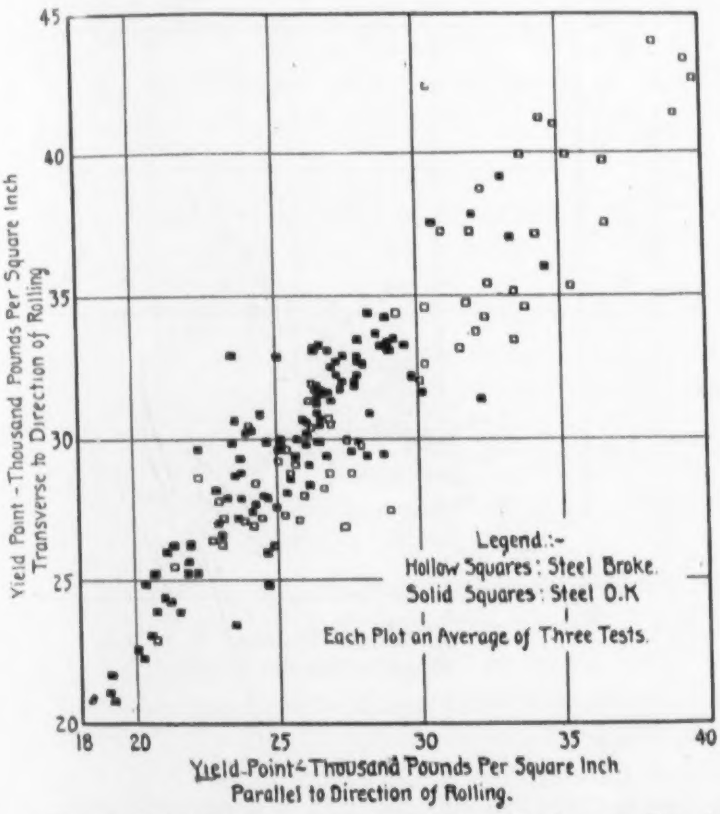


Fig. 5—Yield Points Shown for the Same Steel as in Fig. 1. Test Values Obtained Parallel and Transverse to Direction of Rolling.

Fig. 1. As may be noted, there appears to be no definite relation between this value and the deep drawing properties. If the yield points parallel to and transverse to the direction of rolling are less than approximately 30,000 pounds per square inch and 34,000 pounds per square inch respectively, then the chances that the steel will give satisfactory results appear to be about equal. Extending this observation, there appears to be no exact indication of the

ductility from a drawing standpoint that can be obtained by a bend test or by bending the sheet by hand. If a sheet bends upon application of a small force, the chances appear to be about equal that it will form satisfactorily and a much smaller chance exists if it appears to be stiff.

In Fig. 6 are plotted the ultimate strengths of the steels shown in Fig. 1. Here again there seems to be no exact relation to the deep drawing properties. If the ultimate strengths parallel to the direction of rolling and transverse to the direction of rolling are less

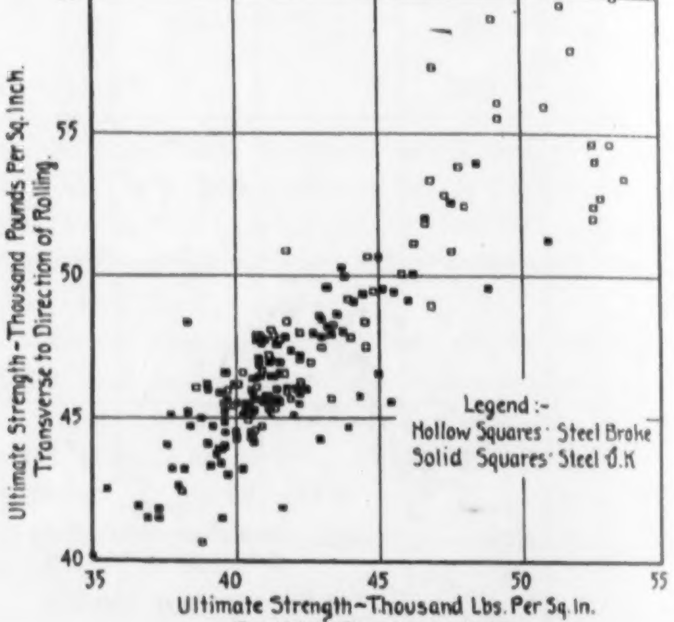


Fig. 6—Ultimate Strengths of the Same Steels as in Fig. 1. Test Values Obtained Parallel and Transverse to Direction of Rolling.

than approximately 46,000 pounds per square inch and 49,000 pounds per square inch, then the chances of the steel being satisfactory appear to be about equal.

The difference in intensity of stress between the ultimate strength and the yield point does not give any indication of the deep drawing properties. The ratio of yield point to tensile strength is considered by many to be of value in determining the ductility of sheet steel. In our experience we have found good drawing qualities in materials in which this ratio differed widely. In general, the more nearly the yield point value approaches fifty

per cent or less of the tensile strength the less is the tendency to form buckles which are difficult to draw out, but on the other hand excellent stampings of difficult design can be made when the yield point is more than sixty-five per cent of the tensile strength. It thus appears that the yield point tensile strength ratio is not very helpful.

In Figs. 7 to 10 are shown the results of the cup test as obtained on an Olsen Cup Testing Machine plotted against the percentage elongation obtained in 2-inch and 8-inch gage lengths. In Figs. 9 and 10 the cup test values have been corrected according to Erichsen's Curve which shows the change in depth of cup with change in thickness of sheet. For the thickness of the steels considered here, this curve can be expressed by the equation:

$$y = 2.4x - 0.3$$

where x = thickness of sheet in inches
y = depth of cup in inches

In these tests all sheets were corrected to correspond to a thickness of 0.060 inches. It may be seen from these charts that no exact or definite relation exists. A very low cup value is usually obtained in a sheet very low in ductility and a very high cup value usually is obtained from a sheet high in ductility, but any value obtained between these two extremes does not give a reliable measure of the deep drawing properties.[2]

There does not appear to be any exact relation between the microstructure and the deep drawing properties. The reductions accompanying cold rolling are usually so small that evidences of this cannot be detected in the shape of the grains and yet one pass through the cold rolls may lower the percentage elongation by 5.0 per cent or more. Fig. 11 shows the structure of a sheet after having been box-annealed and Fig. 12 shows the structure of the same sheet after one pass through the cold rolls.

Figs. 13 and 14 show steels of widely different microstructures and which yielded, respectively, satisfactory and unsatisfactory test results. The former gave good results in the die and the latter gave poor results in the die.

Fig. 14 from a metallurgical point of view would probably be considered as having the "better" structure of the two. The tensile

[2]A discussion of this is given in *Transactions*, A. S. M E., 1926, "The Plastic Behavior of Metals in Drawing", C. L. Eksergian.

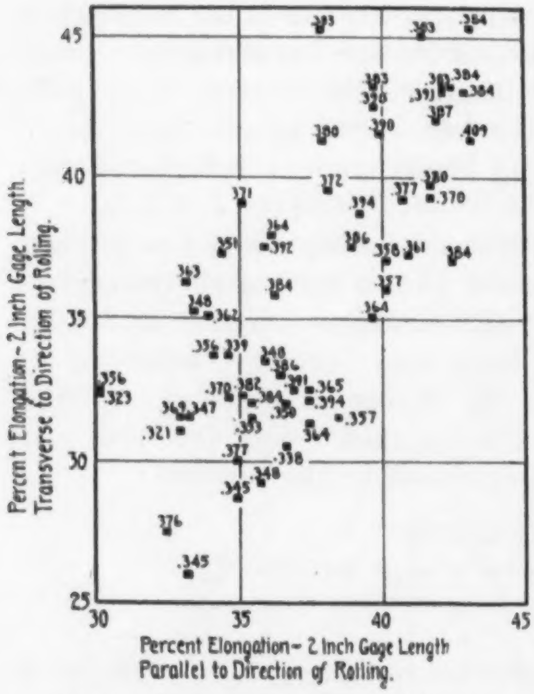


Fig. 7—Per Cent Elongation in 2-Inch Gage Length. Figures Indicate Depth of Cup in Inches, Obtained with an Olsen Cup Testing Machine.

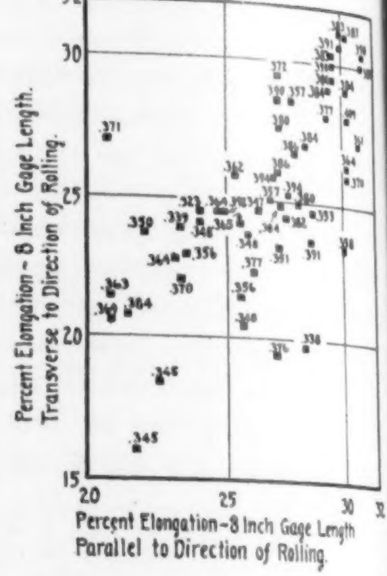


Fig. 8—Per Cent Elongation in 8-Inch Gage Length. Figures Indicate Depth of Cup in Inches, Obtained with an Olsen Cup Testing Machine.

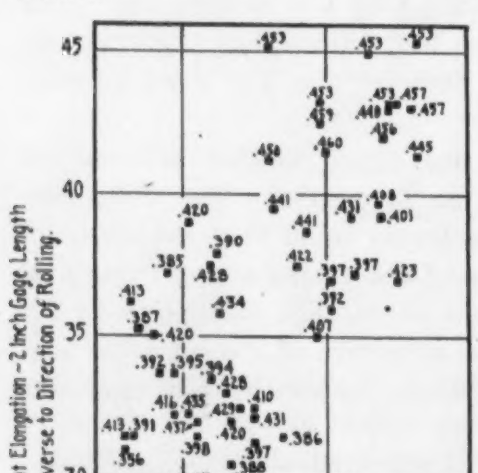


Fig. 9—Per Cent Elongation in 2-Inch Gage Length. Figures Indicate Depth of Cup in Inches, Obtained with an Olsen Cup Testing Machine. Values Corrected According to Erichsen's Curve.

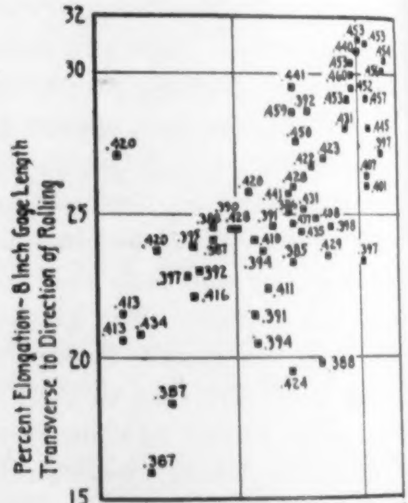


Fig. 10—Per Cent Elongation in 8-Inch Gage Length. Figures Indicate Depth in Inches, Obtained with an Olsen Cup Testing Machine. Values Corrected According to Erichsen's Curve.

test results of the two steels show the inadvisability of relying solely on the microstructure for an exact indication of the drawing properties.

The tensile properties of the steel shown in Fig. 13 were:

Longitudinal				Transverse			
% Elongation 2"	8"	Yield Point	Ultimate Strength	% Elongation 2"	8"	Yield Point	Ultimate Strength
38.2	29.5	22,000	41,000	36.2	28.2	26,200	45,800

The tensile properties of the steel shown in Fig. 14 were:

Longitudinal				Transverse			
% Elongation 2"	8"	Yield Point	Ultimate Strength	% Elongation 2"	8"	Yield Point	Ultimate Strength
35.3	26.1	26,600	40,600	32.5	23.5	32,500	45,400

The strain produced by cold rolling sheets is not usually in itself enough to result in exaggerated grain growth, but when this is coupled with the incomplete removal of cold rolling strains produced at the hot mill, it may be a troublesome factor. Fig. 15 shows the normal grain size of a box-annealed sheet and Fig. 16 shows the size often attained when conditions are such that exaggerated grain growth occurs. Large grain size is not necessarily harmful to the deep drawing properties, but is undesirable for two reasons:

(1) A coarse granular surface is produced on the stamping where the draw is deep.

(2) They favor the occurrence of Stead's rectangular brittleness.[3]

This phenomenon, due to a preferred orientation sometimes produced by cold rolling and subsequent annealing, does not exhibit brittleness, however, unless the stress is applied at certain angles to the cleavage planes. Thus, a sheet may draw perfectly in a preliminary operation and then exhibit extreme brittleness in a subsequent operation in which the application of the stress has been from a slightly different direction.

The condition of the cementite seems to bear no relation to the ductility of the sheet. Sheets in which the cementite is very largely in the spheroidized condition do not necessarily yield better results than those in which pearlite is present. This may also be seen in

[3]Metallography and Heat Treatment of Iron and Steel, p. 285, Dr. Albert Sauveur.

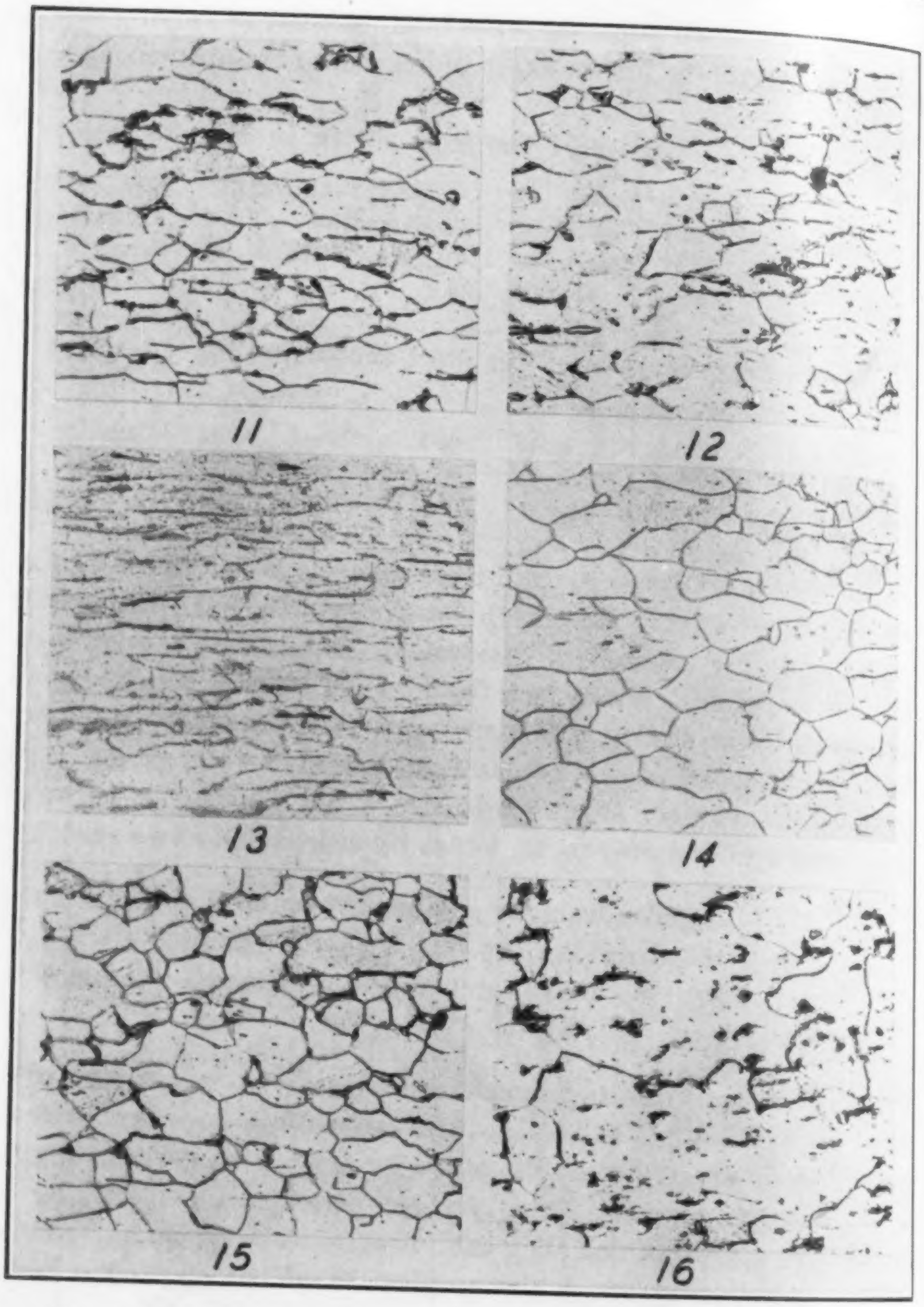


Fig. 11—Photomicrograph of the Structure of a Sheet After Box Annealing. Fig. 12—Photomicrograph of Same Sheet as Shown in Fig. 1 But After One Pass Through the Cold Rolls. Fig. 13—Photomicrograph of Steel Which Gave Good Results in the Die. Fig. 14—Photomicrograph of Steel Which Gave Unsatisfactory Test Results. Fig. 15—Photomicrograph of Sheet Showing Normal Grain Size of Box-Annealed Sheet. Fig. 16—Photomicrograph of Sheet Showing the Grain Size Often Attained When Conditions Are Such as to Cause Exaggerated Grain Growth. Note: All of the above samples etched with nitric acid. Magnification 100 x.

Figs. 13 and 14. The striated structures produced by low hot mill finishing temperatures are not in themselves detrimental to good results. It is believed, however, that each type of structure is affected differently by cold rolling.

Grain size has an effect upon drawing qualities in that sheet showing a small grain size exhibit a greater tendency to buckle in forming. Such sheets require a greater blank-holder pressure. It is, therefore, inadvisable to run steels of large and small grain size in the same die with the same adjustments of blank-holder pressures.

DISCUSSION

Written Discussion: By E. S. Taylerson, American Sheet and Tin Plate Co., Pittsburgh.

The authors are to be congratulated on their very clear presentation of the problems encountered in testing sheet steel as to its suitability for deep drawing purposes. Very close contact with the actual use of the material has enabled them to correlate the results of their laboratory tests with performance in the dies. The lack of this opportunity is one of the handicaps which the sheet steel manufacturer has to attempt to overcome by very close personal contact with his customers.

It has been brought out in a very clear manner that the design of the die is just as important as the quality of the material and that for the successful manufacture of different types of stampings, different physical properties of the steel are required.

The importance of taking a large number of samples has been pointed out. This is a serious obstacle to the development of adequate tests for deep drawing qualities. Considerable variation is often encountered in material which performs perfectly in the dies, and yet if too few test samples had been taken, this same material would have been rejected.

The selection of material for this investigation, from which all or none of the stampings were breaking, has simplified the study of the results. If the average class of material, of which only a small percentage of blanks are broken in the dies, had been included, the data might have been difficult to interpret.

It is believed that this paper will be very useful to those engaged in the deep drawing industry as an aid to explaining their problems, especially in regard to the importance of high general or high local elongation for different types of stampings. General and local elongation can be obtained more accurately from stress deformation diagrams. When the sheet manufacturer is asked to meet specifications for both types of elongation, his difficulties become serious.

The authors' experience with ductility testing machines of the cupping type seems to be the same as that obtained by most users of these machines.

It is believed that nothwithstanding the progress which has been made in testing sheet steel during the last decade, that no one test is likely to prove adequate, which is not at all surprising, considering the large variety

of stampings and the increased demands made on this material by the rapid development in the industry.

The percentage of blanks, which successfully withstand the action of the dies, is at present the only adequate standard for judging the suitability of material for a particular operation. Notwithstanding this condition, it is essential that the development of such tests, as are considered in this paper, should be continued, as great economy would result if it were possible to determine, by laboratory tests, that material was entirely suitable for the purpose in view.

Oral Discussion

F. E. McCLEARY: I would like to ask Dr. Kelley if he stamps the physical test specimen out in a die, and, if he does, whether it is further prepared or machined out, and if there is any difference in the way the test specimen might be taken as to its characteristics in the physical test.

DR. G. L. KELLEY: The test pieces are usually laid out in a transverse direction in such a way as to represent the sheet as well as possible in both the longitudinal and the transverse directions. A total of 6 test pieces are taken. The pieces are cut out to the approximate size by shearing and then they are bunched and milled in a lengthwise direction.

F. E. McCLEARY: You wouldn't recommend stamping it out in a die? That would influence the results?

DR. G. L. KELLEY: It would influence the quality.

ON THE PROPERTIES OF STEELS

(Continued from Page 629)

wheel burning. Certainly in yards and in the vicinity of stations wheel burnt rails are of common occurrence. Thanks to the good qualities of rails, and not the care with which they are used, trains generally pass over such injured track in safety.

In conclusion, practically all grades having been tried and each found breakable, as all steels certainly are, what has been the outcome? Continued increase of wheel pressures. Increase in weight of rails from 100 pounds per yard, with a moment of inertia of say 44, to rails of 200 pounds weight per yard with a moment of 156, diminishes, of course, the fiber stresses under beam action. But such increase in weight is not corrective of intense impinging wheel pressures. Indeed there are reasons for believing that capacity for receiving internal strains from the cold rolling of the wheels increases with the weight of the rail, tending to offset the benefits of the greater volume of metal. The most promising opportunity to achieve improvement in the rail situation seems to repose in the hands of the users of rails by definitely establishing on their part the relations between physical properties of rails and service conditions in the track.

Educational Section

These Articles Have Been Selected Primarily For Their Educational And Informational Character As Distinguished From Reports Of Investigations And Research

THE CONSTITUTION OF STEEL AND CAST IRON SECTION II—PART I

By F. T. Sisco

Abstract

The present installment, the eleventh of the series, is an introduction to the study of the theory of heat treatment. After a brief review of the constitution of steel and cast iron from the standpoint of stable equilibrium, the solid solution of carbon in gamma iron, or austenite is discussed at length. The conflicting views of the internal structure of this constituent are presented. Concluding the installment is a discussion of the grain growth of austenite above the critical range.

Introduction

THE first ten articles of the series on the constitution of steel and cast iron comprised an elementary discussion of the constitution and structure of the alloys of iron and carbon in their natural state, that is, when they are cooled slowly and uniformly from above their melting point to atmospheric temperature. In other words our discussion of the constitution of the iron-carbon alloys postulated a final condition of stable equilibrium; a condition of slow undisturbed cooling which permitted all of the allotropic and other constitutional changes characteristic of these alloys to take place in their regular order.

In the first ten articles of the series we assumed that stable equilibrium resulted in a structure consisting of ferrite and pearlite, or cementite and pearlite in the case of steels; and pearlite and cementite (or pearlite, cementite and graphite) in the case of cast iron. We ordinarily consider the slowly cooled iron-carbon alloys as being stable. Actually, as explained in a previous install-

The author, F. T. Sisco, is Chief of the Metallurgical Laboratories, Air Corps, War Department, Wright Field, Dayton, Ohio.

ment they are metastable; graphite and ferrite is theoretically the stable structural condition. In accordance with customary usage, however, we will use the word "stable" to refer to the slowly cooled alloys and "unstable" to refer to the structural condition of those alloys in which cooling from or above the critical range has been accelerated.

In looking back over our birds-eye view of the constitution of the iron-carbon alloys, (postulated on a condition of stable equilibrium) we find that in this discussion we have been able to proceed logically from the simple to the complex, from concepts easy to understand to more difficult theoretical considerations. Thus our series started with simple crystallization, saturation, and equilibrium, crystal structure, amorphous solids, and allotropy; and proceeded through the determination of cooling curves and the equilibrium diagram; to the solidification of binary alloys whose component metals were insoluble in each other, or soluble in each other in the solid state.

From these elementary concepts it was but a short step to a discussion of the alloys of iron and carbon, proceeding in this from the low carbon alloys, through the medium carbon and high carbon steels, and the low carbon or hypoeutectic cast irons, to the high carbon or hypereutectic cast irons.

We could not leave this discussion of the iron-carbon alloys until we had viewed the effects of the elements, other than carbon, ordinarily encountered in steel and cast iron. Neither could we overlook gray iron, the common product of commerce, in which most of the cementite has broken down into graphite, a still more stable form.

The constitutional changes occurring in the iron-carbon alloys when cooled slowly and uniformly are changes that can be more or less definitely followed by experimental means. As a result of thousands of investigations on these alloys, these changes as summarized in the iron-carbon diagram have been taken from out the realm of conjecture and placed in that of certainty. In most cases, in these changes, we not only know what happens but also we are reasonably sure of the reason. We not only know the effect, we also know the cause. For this we can thank those scientists who have worked so laboriously and painstakingly with their transformation point apparatus, their microscopes and their X-rays.

When we leave the condition of stable equilibrium behind and attempt to discuss the behavior of the iron-carbon alloys from the standpoint of unstable equilibrium we get into difficulties at once. Here we know the effect, but in most cases the cause is still shrouded in mystery.

Suppose we heat a piece of steel containing 0.85 per cent carbon to 1500 degrees Fahr. (815 degrees Cent.) and then let this steel cool slowly and uniformly to atmospheric temperature. During this cooling we can trace the allotropic change that occurs, we know that face-centered gamma iron will hold carbon in solution and we know the appearance and properties of this solid solution. We also know that body-centered alpha iron will not hold carbon in solution, and we know that the carbon is expelled during the change from gamma to alpha iron and in what form the carbon exists in the alloy at normal temperature.

By means of our transformation point apparatus, our microscopes, and our X-rays we have been able to check these changes with a high degree of accuracy. We feel reasonably certain that these various constitutional changes will always proceed in a regular predetermined manner. When our steel is cooled very slowly from 1500 degrees Fahr., (815 degrees Cent.) we know that it will be soft and in addition we know why it will be soft. We are able to trace the changes in structure that are responsible for this softness.

Suppose that now we take our piece of steel, which we had heated to 1500 degrees Fahr. (815 degrees Cent.) and extract the heat very rapidly, by quenching in water. The steel becomes very hard and brittle. We know that quenching in water from 1500 degrees Fahr. (815 degrees Cent.) makes it hard and brittle because we are able to test its hardness, but we do not know with certainty why it is hard and brittle.

We do not know whether this hardness is due to some obscure structural change that we have not been able to trace, we do not know whether the condition of the carbon is repsonsible, or whether other factors enter into the hardness. When we quench a piece of high carbon steel in water we say that martensite is formed. But we are only begging the question because we do not know for sure just what martensite is. We know what it looks like under the

microscope and we know that it is hard but we are not sure what causes the hardness.

When we reheat this hard piece of steel slightly, say to 500 degrees Fahr., (260 degrees Cent.) it becomes softer. We can test the hardness and find it less, and we can easily see that it is less brittle, but we are not certain why. Our standard methods of investigation do not furnish us with any convincing evidence as to what changes are going on within the metal; the only method we have is to theorize, in other words to guess what happens.

There is no doubt but that some day our research workers will be able to tell us why steel hardens; they will be able to confirm their theories by experimental means, but until this happens we must view their theories critically withholding judgment pending more conclusive proof.

The Object of Heat Treatment

The object of heat treatment is to impart desired physical properties to iron or steel through the action of heat. In other words we control the physical properties of iron and steel by (1) heating the material and (2) then cooling it again. If we examine these two requirements for controlling the physical properties it is at once evident that they may be interpreted very loosely; heating and cooling may vary widely in their meaning. We can heat or cool an object uniformly or not, we can heat it to a relatively high or low temperature, and we can heat or cool it rapidly or slowly as we desire.

Heat Treatment thus becomes the science (and art) of imparting desired physical properties to steel through the action of heat but with each variable in applying or extracting the heat closely controlled. It is our object in this and ensuing chapters to discuss these variables entering into heat treatment. In our discussion we will be interested in two things: (1) what happens when we heat treat iron and steel and (2) why it happens. In other words we are concerned first of all with effects and secondly with the causes.

In heat treatment, as was the case in most of our empirical sciences, we have learned what happens by experience, by the costly method of trial and error.

After we have gained our experience and felt sure of the re-

sults we have searched for the causes. In some cases we have found the truth; in other cases we still have only theories, a system of logical reasoning that apparently fits the observed facts.

The heat treatment of iron and steel is divided into four main branches: (1) annealing (2) normalizing (3) hardening and (4) tempering. These four operations result in modifications in structure, but there is practically no change in the chemical composition. In another branch of heat treatment known as case carburizing there is a change in both structure and composition. When steel is heated to a bright red 1600 degrees Fahr. (870 degrees Cent.) or above in the presence of certain forms of carbon, this element will migrate into the steel and increase the percentage of carbon at and near the surface. After the carbon content of the surface areas has been increased to the desired point the material may be subjected to one or more of the other branches of heat treatment; it may be annealed, normalized, hardened or tempered. When a case carburized steel is heat treated the process is commonly known as case hardening.

In studying the various operations in heat treatment we will have to consider three important factors (1) heating the material to the proper temperature; (2) holding the material at the proper temperature for the proper length of time; (3) and cooling the material to atmospheric temperature. In studying these factors we will have to also look at the structural condition of the material before heat treatment, the changes in structure taking place during the three steps outlined above and also, and most important, the structural condition resulting from the treatment. In studying these factors we shall have to pay strict attention to the results of heat treatment and most important of all, try to find logical causes for these results.

In studying the constitution of the iron-carbon alloys when in their normal state, that is, cooled slowly and uniformly from above their critical range, we have become familiar with four metallographic constituents—ferrite, cementite, pearlite, and austenite. When the steel is rapidly cooled, and consequently, when the normal structural changes do not have an opportunity to become completed, we will encounter three more constituents martensite, troostite and sorbite. For the present we will be content to let

them remain simply as names; in the course of our discussion their characteristics and properties will be apparent.

THE SOLID SOLUTION—AUSTENITE

A brief sketch of solid solutions in general[1] and the solid solution of carbon in iron or austenite[2] has been given in former articles. It will be advisable to review some of the facts we have learned and go a little deeper into the internal structure of this important phase of the iron-carbon system.

We have already discussed the allotropic changes in pure iron and the steels when cooled through their critical range. We have learned that pure iron has two critical points in cooling, Ar_3 where gamma iron changes to the beta (?) modification, and Ar_2 where beta iron undergoes transformation to alpha iron. We know that in the steels there is a third or lower critical point Ar_1, which is very faint when the carbon is low and which increases in intensity until it reaches a maximum when the steel contains 0.85 per cent carbon. This lower critical point represents the change of the gamma iron solid solution (austenite) into the aggregate of ferrite and cementite which is known as pearlite.

As the carbon content of the material increases, the position of the upper critical point in cooling, Ar_3, is lowered progressively until it merges with the Ar_2 point. This new combined critical point $Ar_{3.2}$ which appears at about 0.40 per cent carbon, occurs at a progressively lower temperature as the carbon content increases from 0.40 to 0.85 per cent. At this the eutectoid ratio, it merges with the Ar_1 point to form the $Ar_{3.2.1}$ point. As the carbon in the alloy increases the intensity of upper critical points decreases. At the same time, as stated above, the intensity of the Ar_1 point increases to a maximum at the eutectoid point or 0.85 per cent carbon.

Above the upper critical point—A_3[3] for pure iron, $A_{3.2.1}$ for 0.85 per cent carbon steel—iron crystallizes as a face-centered cube known as gamma iron. Alpha iron, the allotropic form stable at atmospheric temperature crystallizes as a body-centered cube.

The geometrical representation of these two forms of crystal

[1]TRANSACTIONS,—American Society for Steel Treating, Vol. 10, Aug. 1926, P. 275-284.

[2]TRANSACTIONS,—American Society for Steel Treating, Vol. 10, Sept. 1926, P. 462.

[3]As noted in a previous installment the letter A is used when we wish to speak collectively of the two points, Ac, the critical point in heating; and Ar, the critical point in cooling.

structure is shown in Figs. 1 and 2 reproduced from a previous installment. In the body-centered lattice one atom is represented as being at each of the eight corners of the cube and one in the exact center. In the face-centered lattice one atom is assumed to be located at each of the eight corners of the cube and one atom in the exact center of each of the six plane faces.

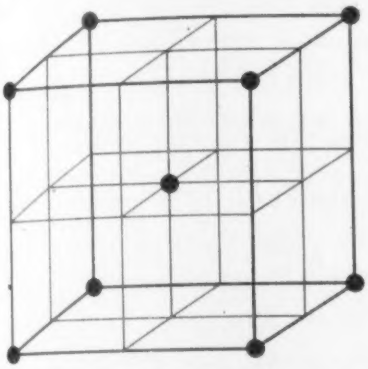


Fig. 1—Body-Centered Space Lattice.

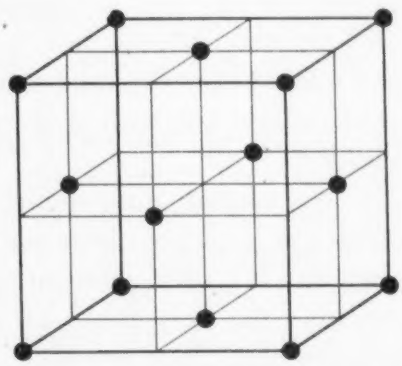


Fig. 2—Face-Centered Space Lattice.

It is thought that these atoms are held together in this geometrical arrangement by strongly attractive forces. These forces are so strong that they tend to prevent the disintegration or distortion of the regular arrangement of the atoms. It follows that any great distortion of the space lattice should theoretically result in a condition of instability.

Evidences obtained by the X-ray indicate that in general in a true solid solution atoms of the solute replace atoms of the solvent without change in the space lattice. As an example of a true solid solution we may take the alloys of copper and nickel. Both of these metals have the same lattice, a face-centered cube with approximately the same lattice dimensions. A solution of copper in nickel or nickel in copper involves no change in space lattice and but little change in lattice dimensions.

Until recently certain binary alloy systems were considered to be true solid solutions and to be soluble in each other in all proportions. Investigation by the X-ray has shown that many of these were mixtures of two or more solid solutions. An example of this is the binary system nickel-chromium. We can add as much as 65 per cent chromium to nickel and still find only the face-centered lattice of the nickel. Between 65 and 93 per cent

chromium we can detect two distinct lattices, the face-centered of the nickel, and the body-centered of the chromium. Between 93 and 100 per cent chromium the lattice is the body-centered cubic of chromium.

X-ray analysis has given us positive information as to the internal structure of many of our alloy systems. In the question of the constitution of austenite it has not been so valuable. It has told us that gamma iron crystallizes as a face-centered cube; it has told us that the solid solution austenite has also a face-centered cubic lattice but with that information we must for the present be content.

We cannot state definitely that austenite is a solid solution of carbon in gamma iron nor can we state with equal assurance that austenite is a solid solution of iron carbide in gamma iron. In fact, probably the only thing we are sure of is that austenite is a solid solution and there are many of us who would not stake our lives on that.

Sauveur from a questonnaire sent to leading metallurgists of the world on the theory of hardening, reports that the opinion is generally held that austenite is a solid solution of iron carbide in gamma iron. Jeffries and Archer[4] maintain that it is carbon in solid solution. They state:

> "Until recently it was customary, though not at all universal, to consider that compounds of metals dissolve 'as such' in the solid solvent. The iron-carbon solid solution, austenite, for example, is usually spoken of as a solution of iron carbide or cementite in iron, and it was formerly the general view that the carbon in this solution was in the form of carbide molecules. This view now seems highly improbable in the light of new knowledge of the constitution of solid solution and the internal structure of metals.
>
> Most of the compounds of metals which are found in alloy seem to occur only in the solid crystalline state, and there is no evidence of the existence of any definite unit of such substances which can be called a molecule.
>
> Even granting that compound molecules may exist, they would be too large to diffuse through the rigid space lattice of the solvent metal. Carbon readily diffuses through iron,

[4]Science of Metals, 1924, Page 266.

but can scarcely do so in the form of molecules of iron carbide (empirical formula, Fe_3C), which would have to contain at least 3 atoms of iron and 1 of carbon. The carbon atoms alone must be the ones which diffuse.''

It is evident at the outset of our discussion of the iron-carbon alloys from the standpoint of unstable equilibrium that we are faced with a debatable problem that has a vital bearing on the question of the hardening of steel. Many of the theories of hardening stand or fall on the thesis that iron carbide is or is not in solution in gamma iron.

Westgren and Phragmen have done a vast amount of important work on the constitution of austenite. In regard to cementite they found the crystallogram contained a large number of lines and that space lattice was apparently unsolvable. From recent investigation by these two scientists[5] they conclude that the lattice dimensions of austenite increase in size with increasing carbon content. This would indicate that the austenite is not a true solid solution, with carbon atoms replacing the iron atoms in the face-centered lattice. Instead, and this belief is held by many—the carbon atoms are situated in the interstices between the iron atoms. The density calculated from X-ray data apparently upholds this view.

On the other hand, to believe that carbon is dissolved in gamma iron, is to postulate an easily reversible chemical reaction.

$$Fe_3C \rightleftarrows 3Fe + C$$

We know definitely that pearlite contains iron carbide, Fe_3C. If austenite contains carbon instead of iron carbide in solid solution, the Ar_1 point not only marks the change of the face-centered gamma iron to body-centered alpha iron but it also marks the formation of Fe_3C., and conversely the Ac_1 point marks the dissociation of Fe_3C. From what we know of iron carbide it seems certain that its easy formation is much less certain than its easy dissociation.

In connection with the A_1 transformation Sauveur states:[6]

> ''In recent years, however, it has seemed more and more probable to many students of metallography that it is not carbon in its elementary state which is dissolved in iron at a high temperature, but rather the carbide Fe_3C itself, and the

[5]*Journal*, Iron and Steel Institute, 1924, Vol. 109, P. 159-174.

[6]Metallography and Heat Treatment of Iron and Steel, 1926, P. 118.

difference between the behavior of the carbon in hardened steel and in slowly cooled steel might well be satisfactorily accounted for on the ground that in hardened steel Fe_3C is *dissolved* in iron and in that form is much more readily acted upon by acids, being thereby converted into hydrocarbons, whereas Fe_3C when in the free crystallized condition, as in slowly cooled steel, resists the action of the acids and remains undissolved. If it is Fe_3C and not C which is dissolved in iron above the critical range, it is evident that the point Ar_1 cannot be caused by the *formation* of Fe_3C. But it may well be due to the crystallization or falling out of solution of Fe_3C. To be sure this is a falling out of a solid solution, but cannot we conceive that the falling out of a constituent of a solid solution is accompanied by an evolution of heat even if it does not imply a change of state? In other words is it not possible, or even probable, that crystallization in a solid state is accompanied by an evolution of heat? Surely this crystallization implies an allotropic or at least a polymorphic transformation, and are not such transformations always accompanied by heat evolutions?

The author offers these thoughts as possibly worthy of attention and as a possible explanation of the evolution of heat at Ar_1 if we assume that Fe_3C and not C is dissolved in iron above that point."

The view that Jeffries and Archer hold in regard to the solid solution of carbon in gamma iron is founded on the assumption that compound molecules are too large to diffuse through the rigid space lattice of the solvent. In other words carbon can migrate into the space lattice but iron carbide cannot.

If we assume that the carbon atoms are held interstitially the austenitic solid solution cannot be spoken of as being in equilibrium, at least not in the strictest sense of the word. We may say the austenite is in equilibrium but is held in equilibrium by its rigidity, in other words by its high viscosity. Dr. H. H. Lester has called this condition pseudo-equilibrium.

If we can picture iron carbide dissociating easily into iron and carbon and the carbon atoms migrating into the gamma iron lattice; why is it not as easy to conceive that iron carbide molecules

enter the gamma iron lattice direct and replace three iron atoms. Whether one assumption or the other is taken for granted depends upon how much value we place on density determinations on high manganese and high nickel austenite steels.[7]

After sifting all of the evidence pro and con, we can define austenite as (1) an atomic distribution of carbon atoms interstitially located in the face-centered crystal unit of the gamma iron; or (2) a solid solution of iron carbide in gamma iron.

When we consider the various theories of hardening in a subsequent installment we will have occasion to refer to these two definitions again.

The structure and properties of austenite have already been described in a previous installment.[8]

Grain Growth of Austenite

In a previous installment we have seen that when a metal solidifies the atoms or molecules arrange themselves in definite geometrical patterns called crystals. Crystallization starts at numerous nuclei and spreads in three dimensions until arrested by contact with a neighboring crystal mass. The result is a structure composed of irregular polyhedral grains, such as shown in Figs. 3 to 6. Each of these grains is made up of crystalline material similarly oriented in the same grain but differently oriented in different grains.

Above the critical range steel is composed of a solid solution of carbon or iron carbide in gamma iron. This solid solution, austenite, crystallizes in polyhedral grains in much the same manner as a pure metal. If steel is held for a long period of time at a temperature well above the critical range the austenite grains will grow in size.

Under the influence of temperature and time the orientation of the grains gradually changes. When it so happens that two adjacent grains have the same orientation the grain boundary disappears and the two grains merge into one. If the material is heated to a sufficiently high temperature for a sufficient time, theoretically one single grain would result. This occasionally happens in meteorites.

[7]Dowdell and Harder—Decomposition of the Austenitic Structure in Steel, Transactions, American Society for Steel Treating—Vol. 11, Jan. 1927, P. 20.

[8]Transactions, American Society for Steel Treating, Vol. 10, Sept. 1926, P. 462-464.

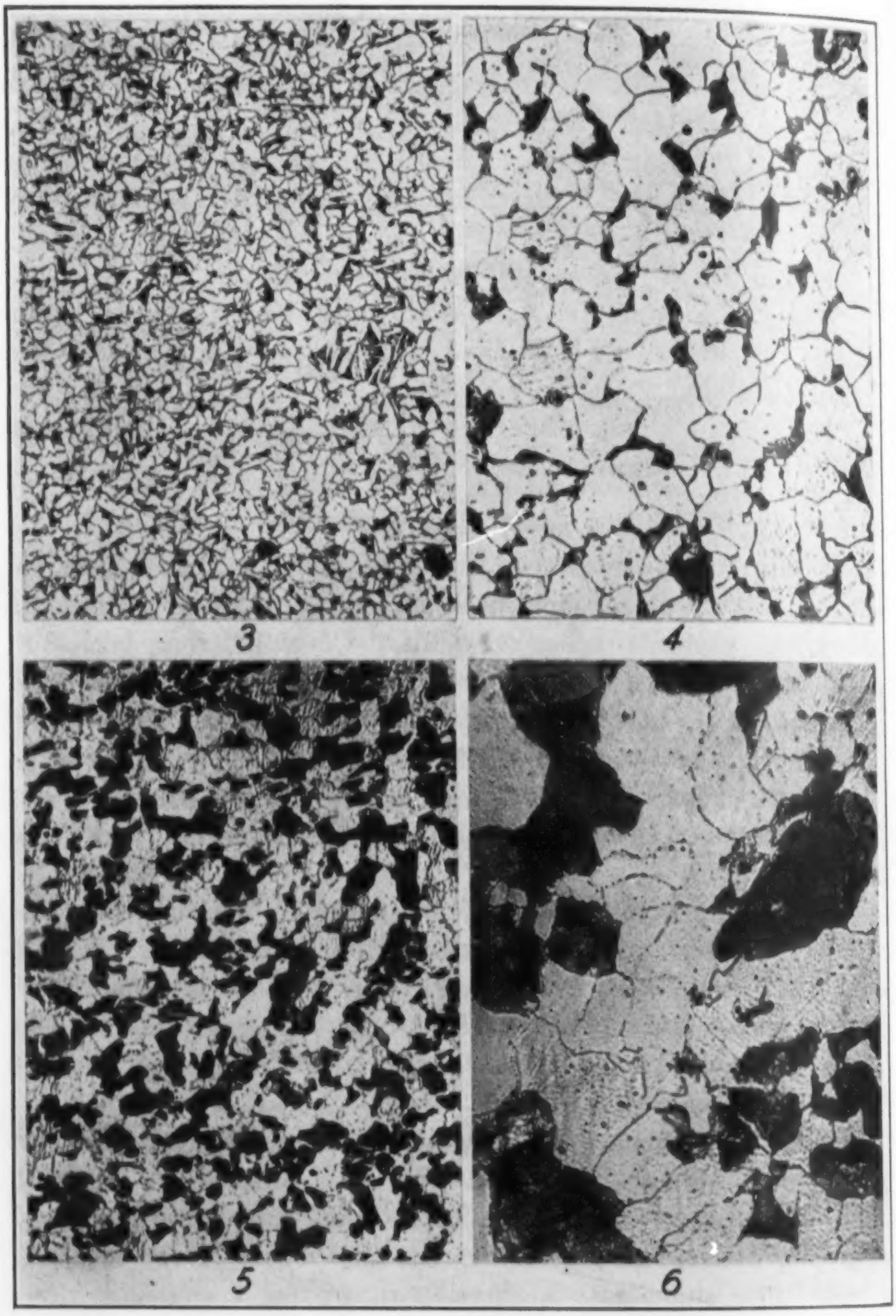


Fig. 3—Photomicrograph of a 0.10 Per Cent Carbon Steel After Being Heated to 1500 Degrees Fahr. Specimen Etched in Alcoholic Nitric Acid. 100 x. Fig. 4—Photomicrograph of a 0.10 Per Cent Carbon Steel After Being Heated to 2200 Degrees Fahr. Specimen Etched in Alcoholic Nitric Acid. 100 x. Fig. 5—Photomicrograph of a 0.26 Per Cent Carbon Steel After Being Heated to 1500 Degrees Fahr. Specimen Etched in Alcoholic Nitric Acid. 100 x. Fig. 6—Photomicrograph of a 0.26 Per Cent Carbon Steel After Being Heated to 2200 Degrees Fahr. Specimen Etched in Alcoholic Nitric Acid. 100 x.

From this it is evident that on slow cooling the coarse granular condition will persist to some extent at least and the resulting structure will also be coarse grained. Jeffries states[9] that:

> "The ferrite grain size in pure iron, the ferrite and pearlite grain size in hypoeutectoid steel, the pearlite grain size in eutectoid steel, and the cementite and pearlite grain size of hypereutectoid steel are not inherited from the grain size of the mother austenite."

On the other hand he states that, "in general, both in iron and in carbon steel, the larger the austenite grains the larger will be the grain size of the transformation products on cooling. This, of course, assumes all other conditions constant except the austenite grain size."

The effect of temperature on the final grain size of two samples of low carbon steel is shown in Figs. 3 and 4. The magnification is 100 diameters. The carbon content of this specimen is 0.10 per cent. The structure shown in Fig. 3, is the result of air-cooling the specimen from 1500 degrees Fahr. (815 degrees Cent.); the structure of Fig. 4 is the result of air-cooling from a temperature of 2200 degrees Fahr. (1204 degrees Cent.). In both cases the samples were held at the specified temperature for the same length of time.

Figs. 5 and 6 at 100 diameters show the structure of a 0.26 per cent carbon steel heated to the above temperature. In this case the specimens were cooled slowly in the furnace.

Figs. 7, 8 and 9 show the structures of a 0.25 per cent carbon steel. Fig. 7 shows the structure of the material as received, and Figs. 8 and 9 after cooling slowly from 2000 degrees Fahr. The sample shown in Fig. 8 was held one hour at the specified temperature; the sample shown in Fig. 9 was held 5 hours.

Fig. 10 reproduced from Sauveur[10] is an excellent example of grain growth above the transformation range. This structure is that of a 0.50 per cent carbon steel held two hours at 2100 degrees Fahr. (1150 degrees Cent.) and cooled in air. In describing this structure Sauveur states that, "the very large sorbitic grains formed prove the existence above the range of equally large, or even larger, austenitic grains."

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[9] *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 58, P. 669.

[10] Loc. Cit. P. 199.

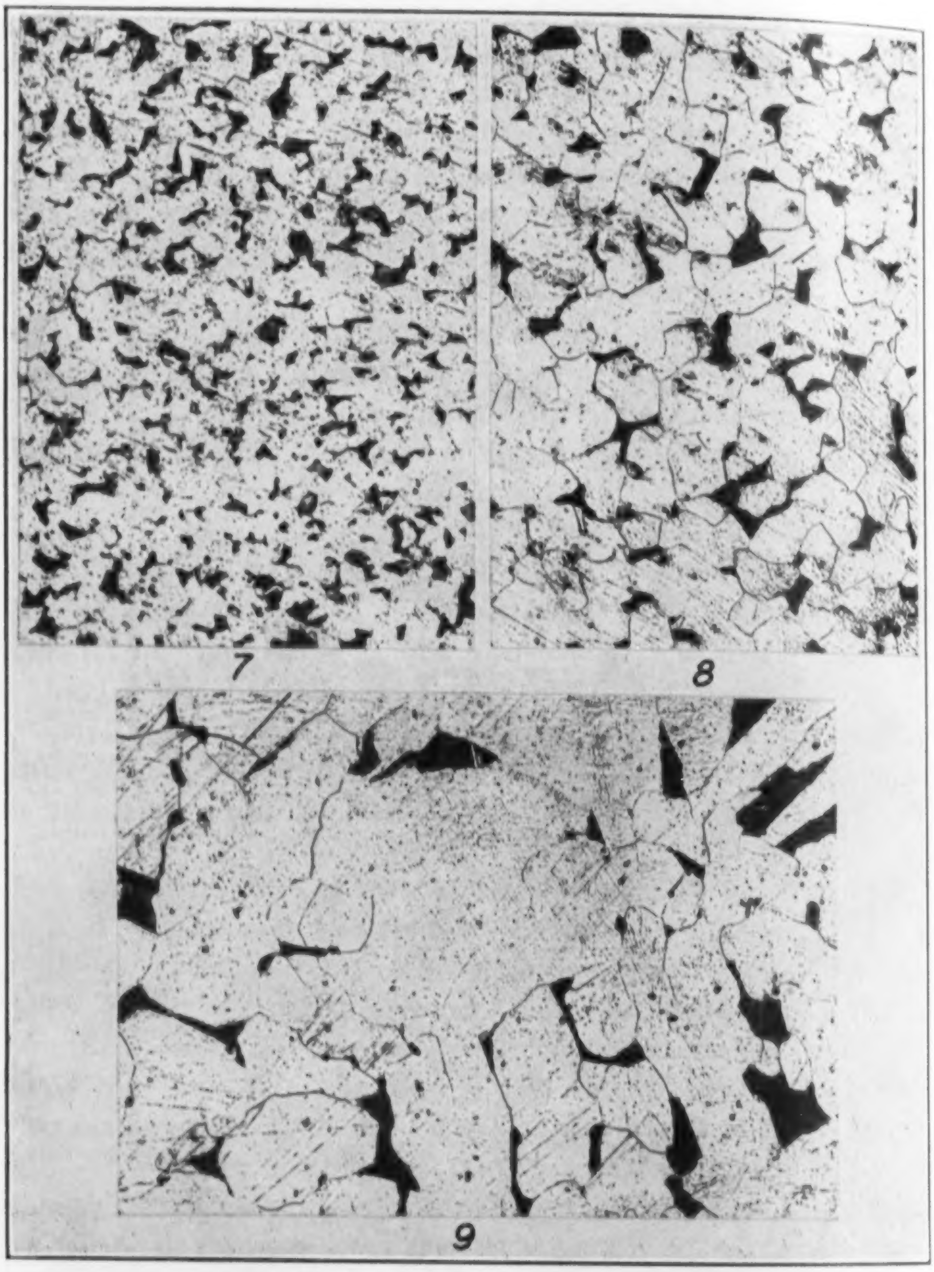


Fig. 7—Photomicrograph of a 0.25 Per Cent Carbon Steel as Received (Probably Hot-Rolled). Specimen Etched in Alcoholic Nitric Acid. 100 x. Fig. 8—Photomicrograph of a 0.25 Per Cent Carbon Steel, Heated to 2000 Degrees Fahr. and Held for 1 Hour. Specimen Etched in Alcoholic Nitric Acid. 100 x. Fig. 9—Photomicrograph of a 0.25 Per Cent Carbon Steel Heated to 2000 Degrees Fahr. and Held for 5 Hours. Specimen Etched in Alcoholic Nitric Acid. 100 x.

The grain growth of the austenitic solid solution above the critical range is of vital importance in successful heat treatment.

The final quality of a heat treated tool or other valuable part is in a large measure dependent upon the grain size. And since the grain size of the austenite has a great influence on the final grain size of the steel at atmospheric temperature it is important that

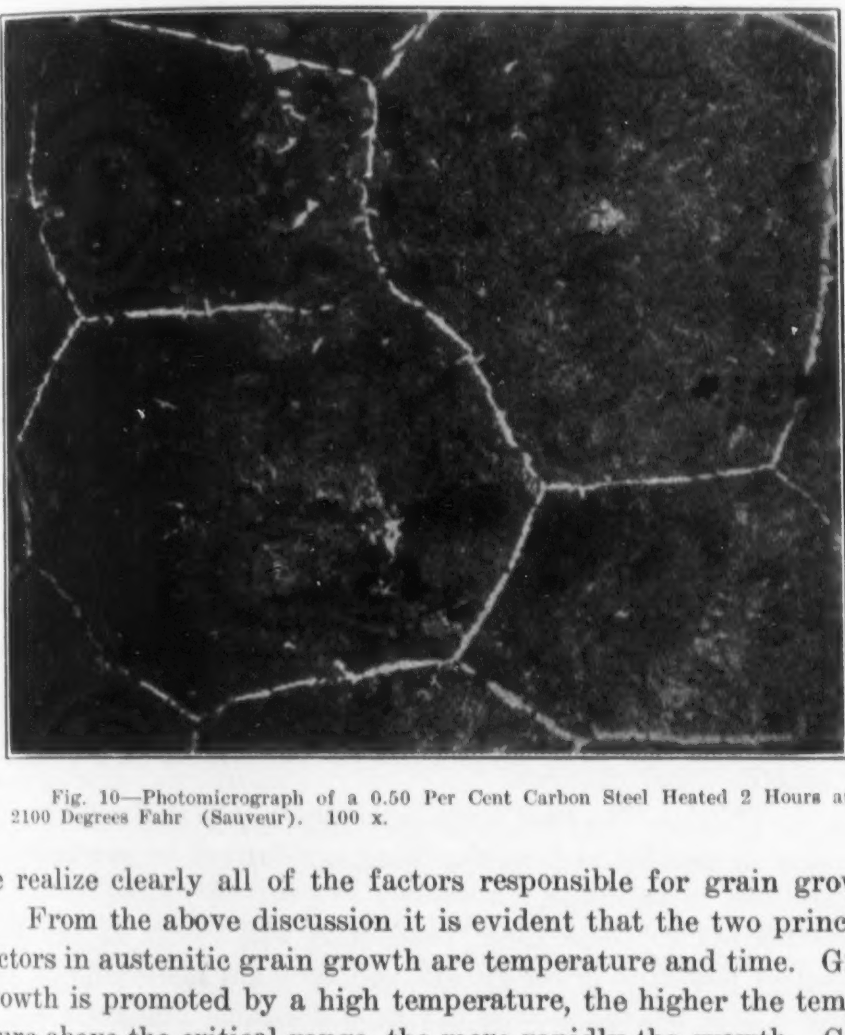


Fig. 10—Photomicrograph of a 0.50 Per Cent Carbon Steel Heated 2 Hours at 2100 Degrees Fahr (Sauveur). 100 x.

we realize clearly all of the factors responsible for grain growth.

From the above discussion it is evident that the two principal factors in austenitic grain growth are temperature and time. Grain growth is promoted by a high temperature, the higher the temperature above the critical range, the more rapidly the growth. Grain growth is also proportional to the time. If the temperature remains constant, the longer the time at temperature the greater the growth.

In addition to the effect of temperature and time Jeffries[11] calls attention to several other factors. The first of these factors is: "The larger the ferrite, cementite or pearlite grain in steel, the larger will be the austenite grain size on heating above the Ac

[11]Loc. Cit. P. 371.

transformation." In other words, a steel having a large grain structure at atmospheric temperature will, when heated through the transformation range, have a larger austenite grain than one with a small grain size.

The second factor is: "The faster the rate of heating of iron and steel, other conditions remaining the same, the smaller will be the austenite grain size."

In heat treatment it is very essential that we regulate the various operations of heating and cooling so that we will have the finest grain in the finished material that it is possible to produce, consistent with the mechanical properties desired. In order to produce a fine grained structure we must regulate the temperature to which we heat the material, the time that we hold the material at temperature and the rate of heating. All three of these variables are important.

Having learned the effects of these variables on the grain growth of austenite, we can now formulate general conditions to control this grain growth.

First:—In heat treatment we must heat to the lowest temperature at which all of the allotropic and constitutional changes desired will take place.

Second:—We must hold the steel at this temperature for the shortest possible time; just long enough for the heat to penetrate to the center of the piece and complete the required constitutional changes.

Third:—The steel must be heated to the desired temperature as rapidly as possible, being careful not to overheat any sections in so doing.

Attention to these three conditions will result in the least amount of austenite grain growth and thus aid materially in producing a heat treated section having a desirable fine grain.

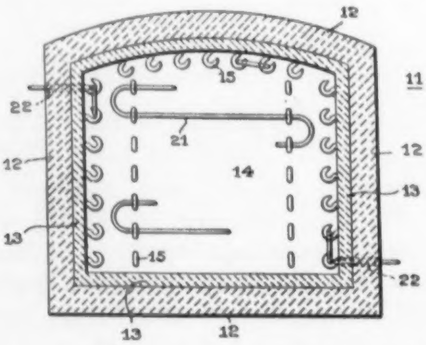
It is also essential that the steel to be heat treated is as fine grained as possible. As hot rolled or forged steel is usually heterogeneous in structure it is nearly always necessary to refine the grain before further heat treatment. This is done by normalizing or annealing or both. This will be taken up in the next installment.

Reviews of Recent Patents

By NELSON LITTELL, Patent Attorney
475 Fifth Ave., New York City—Member of A. S. S. T.

1,638,822, **Electric Resistance Furnace, Herman M. Biebel, of Oakmont, Pennsylvania, Assigner to Westinghouse Electric & Manufacturing Co., a Corporation of Pennsylvania.**

This patent describes an electric resistance furnace in which the resistance grids, being connected together at the ends, are supported from the inner lining 13 of the furnace by means of hooks 15 which project through



the slots in the inner lining and are removably retained therein so as to permit the location of the hooks 15 being changed at will and the arrangement of the resistance wires 21 varied. 22 indicates the end of the resistance wires projecting through the walls of the furnace for connection with a suitable source of current.

1,638,855, **Alloy, Louis Jordan and George Willard Quick, of Washington, District of Columbia, Assignors to The United States of America, Represented by the Secretary of Commerce.**

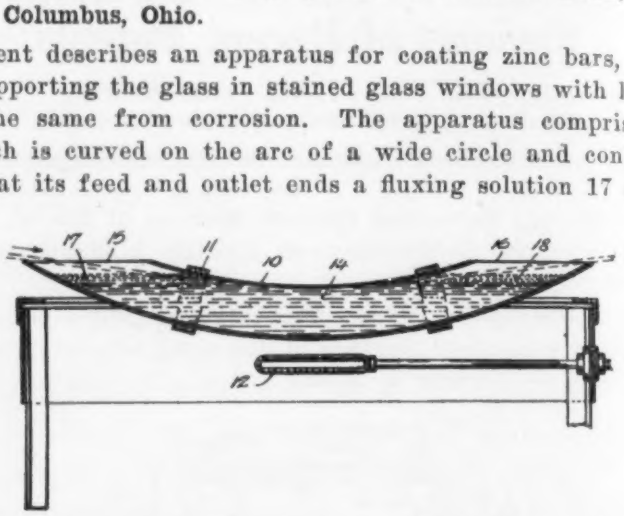
This patent is dedicated to the public and may be used by all without fear of infringement. The patent describes an alloy having great hardness combined with malleability and toughness, capable of being further hardened by heat treatment without becoming brittle and of still further hardening by cold working after hardening by heat treatment. A particular object of the invention is to provide an alloy for the preparation of balls for use in measuring the Brinell hardness of extremely hard steels, or for other purposes. The alloy preferably is of the following composition:

Carbon	2.93	Sulphur	0.016
Vanadium	13.5	Silicon	1.55
Manganese	0.10	Iron, balance to 100	

The percentage of carbon may be varied from 2 to 4 per cent and of vanadium from 10 to 15 per cent.

1,638,882, Apparatus for Coating Zinc Bars With Lead, Adolph H. **Rossbach, of Columbus, Ohio.**

This patent describes an apparatus for coating zinc bars, particularly for use in supporting the glass in stained glass windows with lead in order to protect the same from corrosion. The apparatus comprises a closed tank 10 which is curved on the arc of a wide circle and contains molten lead 14 and at its feed and outlet ends a fluxing solution 17 and a clean-



ing solution 18 floating upon the surface of the heavier molten lead. The tank is supported by means of clamps 11 over a suitable burner 12 for keeping the contents molten and the zinc bars are passed through the tank, as indicated by the dash line, first contacting with the fluxing solution, then with the molten lead and finally with the cleaning solution. The shape of the tank permits the bars to be passed through without substanial bending and the curvature of the tank assures that all parts of the bar will be covered and coated with the lead.

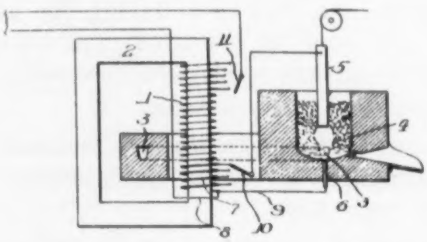
1,639,330, Method of Making Alloys, Jean H. L. De Bats, of East **Orange, New Jersey, Assignor to De Bats Metals Co., of Bloomfield,** New **Jersey, a Corporation of New Jersey.**

This patent describes a method of making alloys of nickel, chromium and tungsten, which comprises placing two pounds of shot nickel in a crucible and on top of this a thorough mixture of four pounds of crushed chromium and four pounds of tungsten powder. The charge is placed in a high frequency induction furnace where the nickel is quickly reduced to a molten condition and being covered with chromium and tungsten superheats rapidly. After sufficient heating of the molten nickel, the chromium and tungsten are rapidly stirred into the molten nickel by poking or thrusting a rod repeatedly and quickly down through the mixture of chromium and tungsten. When the powdered mixture is thoroughly mixed with the nickel, the cover is replaced on the crucible and the mass is allowed to heat for several minutes, at the end of which time the slag may be removed and the metal poured into ingot molds.

1,639,340, Combination Induction Furnace, Albert E. Greene, of Seattle, **Washington.**

The original application for this patent was filed on January 3, 1913 and renewed December 19, 1917. The patent describes a combination arc and induction furnace in which the arc may be used for the preliminary

melting and the induction heat for the further refining of the metal. The patent also describes the method of control of the voltage to the arc, as well as the voltage induced in the induction furnace. In the figures shown, the winding 1 is wound on a magnetic core 2 and is connected to a supply of single phase alternating current. Around the magnetic core is a refractory crucible with a channel 3 encircling the core for holding a single portion of the molten metal secondary. One portion of the channel 3 is



enlarged to form a pot 4 in which the ore is reduced and melted and the pot is provided with an adjustable electrode 5, together with a fixed electrode 6 for the preliminary melting. Controls 10 and 11 are provided for connection with taps into the winding 1 for controlling the voltage to the arc circuit and the voltage to the induction coil.

1,639,694, **Process of Rust Proofing and Articles Produced Thereby, Matthew Green, of Detroit, and Hobart H. Willard, of Ann Arbor, Michigan, Assignors to Parker Rust-Proof Co., of Detroit, Michigan, a Corporation of Michigan.**

This patent describes the solution and method of rust proofing iron or steel articles by producing a coating of insoluble phosphates thereon in which a larger portion of the phosphates is of the normal or dihydrogen phosphate instead of the monohydrogen phosphate. This condition is brought about by providing a solution in which the manganese content is more than one-half the iron content of the dissolved phosphates. The coating is described as being much more resistant to rusting than coatings consisting of the usual monohydrogen phosphates.

1,639,989, **Alloy Steel and Method of Making It, Charles Tyndale Evans, of Titusville, Pennsylvania.**

This patent describes an alloy which is non-corrosive in its ingot form as well as in its subsequent stages and therefore does not have to undergo a hardening treatment and polishing in order to develop the stainless properties. It is also easier to forge and less difficult to work than the higher chromium steels. In the preferred composition, the alloy is as follows, with the usual impurities of phosphates and sulphur as low as possible:

Carbon	0.40	Manganese	0.75
Chromium	7.50	Silicon	1.25
Nickel	19.50		

The principal remaining ingredient is iron.

1,641,326, Process of Remelting Chromium Steel Scrap, Walter M. **Farnsworth, of Canton, Ohio, Assignor to Central Alloy** Steel Corp., of **Massillon, Ohio, a Corporation of New York.**

This patent describes a process of remelting steel scrap under conditions to preserve the same chromium and carbon content as the initial scrap, which comprises adding an amount of ferro-silicon to the charge at the beginning of the melting down period, which is sufficient to prevent the absorption of carbon in the bath during the melting down by the maintenance of strongly reducing conditions and adding more ferro-silicon to the bath after the metal has been melted down to prevent recarburization at subsequent stages of the process.

1,641,752, Oxidation-Resisting Material, Rudloph F. Flintermann, of **Detroit, Michigan, Assignor by Mesne Assignments, to** General Electric **Co., a Corporation of New York.**

This patent describes a metallic alloy which is resistive to oxidation at high temperatures and which is particularly adapted for resistance elements. It is a ferrous alloy having an aluminum content of from 12 to 20 per cent and at least 1 per cent of titanium.

1,633,258, Refractory Metal Alloy of High Density and High Melting **Point and Method of Making the Same, Clemens A.** Laise, Haworth, **N. J.**

This metallic body comprises a porous compressed mass of tungsten and a decomposed nitride of refractory metals, a base metal being used to fill the pores of the mass.

1,627,682, Method and Apparatus for Heat Treating Steel Articles, **John F. Wyzalek, Arlington, N. J., Assignor to General** Motors Corporation, **Detroit, Mich.**

This apparatus for heat treating steel articles comprises a furnace having a tube extending through the heating chamber, with a second furnace spaced from the first and also having a tube extending through the heating chamber. An unheated tube section joins these furnace tubes.

1,627,735, Method and Apparatus for Generating and Controlling Heat, William S. Hadaway, Jr., New Rochelle, N. Y.

An oxygen carrying medium is passed into a fuel at a temperature higher than the ignition point of the fuel in this apparatus, the products of combustion being passed through a heat exchange member to cause them to give up their heat to the incoming medium.

1,630,045, Centrifugal Casting of Metals, Lucien I. Yeomans, Chicago, **Ill., Assignor to A. O. Smith Corporation, Milwaukee, Wis.**

In this process of metal casting the molten metal is poured into a mold, and the casting withdrawn after the temperature has reached the point of congelation. The normal temperature of the mold is restored by the application therein of a measured quantity of water which in its evaporation will abstract from the mold the heat units imparted by the molten metal.

THE ENGINEERING INDEX

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Arrangements have been made with The American Society of Mechanical Engineers whereby the American Society for Steel Treating will be furnished each month with a specially prepared section of The Engineering Index. It is to include items descriptive of articles appearing in the current issues of the world's engineering and scientific press of particular interest to members of the American Society for Steel Treating. These items will be selected from the copy prepared for the annual volume of the Index published by the A. S. M. E.

In the preparation of the Index by the staff of the A. S. M. E. some 1,200 domestic and foreign technical publications received by the Engineering Societies Library (New York) are regularly searched for articles giving the results of the world's most recent engineering and scientific research, thought, and experience. From this wealth of material the A. S. S. T. will be supplied with a selective index to those articles which deal particularly with steel treating and related subjects.

Photostatic copies (white printing on a black background) of any of the articles listed may be secured through the A. S. S. T. The price of each print, up to 11 by 14 inches in size, is 25 cents. Remittances should accompany orders. A separate print is required for each page of the larger periodicals, but whenever possible two pages will be photographed together on the same print. When ordering prints, identify the article by quoting from the Index item: (1) Title of article; (2) name of periodical in which it appeared; (3) volume, number, and date of publication of periodical; and (4) page numbers.

ALLOY STEELS

COPPER IN. High Copper in Steel Produces Poor Product. Iron Age, vol. 120, no. 8, Aug. 25, 1927, p. 468. German steel made from copper-bearing pig irons; sheet steel from this iron less amenable to dishing; surface is rough.

COPPER STEEL. Corrosion Resistance of Copper Steel. Metallurgist (Supp. to Engr.), Aug. 1927, pp. 121-123, 2 figs. From an article by Dr. Daeves, in Stahl u. Eisen, no. 52, 1927, p. 1857.

DETERIORATION. Deterioration of Alloy Steels in Ammonia Synthesis, J. S. Vanick. Chem. & Met. Engr., vol. 34, no. 8, Aug. 1927, pp. 489-492, 3 figs. Deterioration during the synthesis of ammonia of materials which originally possessed the requisite physical properties.

MANGANESE. Alloys of Iron and Manganese Containing Low Carbon, Robert Hadfield. Iron and Steel Inst.—Advance Paper, May 1927, 65 pp. and supp. plates, 17 figs. Report of a research to ascertain definitely the properties conferred by manganese itself upon iron in the practical absence of carbon. See also Engineering, vol. 124, nos. 3211 and 3212, July 29 and Aug. 5, 1927, pp. 148-151 and 184-186, 13 figs.

ALUMINUM

ALUMINA IN. Alumina in Aluminium and Its Light Alloys, R. J. Anderson. Metal Industry (Lond.), vol. 30, nos. 13 and 14, Apr. 1 and 8, 1927, pp. 337-339 and 359-360. Apr. 1: Allowable limits of alumina; removal of entrained oxide; oxidation of aluminium; dross loss in melting practice; alumina and other inclusions; Apr. 8: Oxidation film on castings; removal of alumina and other inclusions from melts; resume and conclusions.

CONSTITUTION AND PROPERTIES. Aluminum Bronze, J. Strauss. Am. Soc. for Steel Treat.—Trans., vol. 12, no. 2, Aug. 1927, pp. 239-273 and (discussion) 273-278 and 306, 8 figs. Present paper is a review of constitution, mechanical properties and resistance to corrosion of these aluminum-copper alloys with and without addition of other elements; it is intended to provide those who up to present time have been largely interested in steel and its heat treatment, with a survey of a portion of the nonferrous field in which mechanical properties, heat treatment practice and other features are closely allied to those of some common ferrous products.

ALUMINUM ALLOYS

"ALCLAD." "Alclad" A New Corrosion Resistant Aluminum Product, E. H. Dix. Nat. Advisory Committee For Aeronautics—Tech. Notes, no. 259, Aug. 1927, 13 pp., 13 figs. It is purpose of this paper to describe a new corrosion resistant aluminum product which is markedly superior to present strong alloys; its use should result in greatly increased life of structural part; product, designated "Alclad," has been in course of development by the Research and Technical Departments of the Aluminum Company of America for some time.

TREATMENT OF. Attainment of Maximum Strength in Fabricating Treatable Aluminum Alloys (Die Erzielung von Festigkeitshöchftwerten bei der Fabrikation vergütbarer Alum.-Legierungen), P. Schwerber. Zeit. für die Gesamte Giessereipraxis, vol. 48, nos. 29 and July 17 and pp. 117-118. General discussion of chemical and heat treatment processes in fabricating such alloys as duralumin and others.

AUTOMOBILES

STUDEBAKER. Studebaker Axles and Crank Shafts, F. W. Manker. Iron Age, vol. 120, no. 6, Aug. 11, 1927, pp. 332-334, 3 figs. Normalized and hardened in contin-

uous furnaces, oil fired and with recuperators, giving 42 per cent gross efficiency.

AXLES

CAR, FATIGUE CRACKS. A Study of Fatigue Cracks in Car Axles, H. Moore. Eng. Experiment Station—Univ. of Illinois Bul., vol. 24, no. 41, June 14, 1927, 22 pp., 9 figs. This study has been planned to secure an answer to following questions: can a fatigue crack in car axle be detected in the early stages of its development, so that axle may be removed from service before fatigue failure is imminent? if a fatigue crack has started in car axle under occasional high stress, will it spread under subsequent repetitions of ordinary working stress? If a fatigue crack has started in a car axle is it safe practice to turn down axle to a diameter smaller than that at bottom of crack, and then to continue axle in service under lighter loads? In this bulletin is a discussion of tests results bearing on questions (1) and (2); experiments bearing on question (3) are in progress, but no definite conclusions have been reached as yet.

BLAST-FURNACES

BRITISH PRACTICE. British Blast-Furnace and Cupola Practice, J. E. Fletcher. Foundry Trade Jl., vol. 36, no. 18, Aug. 18, 1927, pp. 153-154. Fuel economy in furnace and cupola; need to utilize maximum heat.

PRACTICE. Effect of Relative Coarseness of Charge on Blast Furnace Processes (Die Abhängigkeit der Vorgänge im Hochofen von der Stückgrösse der Beschickungsstoffe), Diepschiag. V. D. I. Zeit., vol. 71, no. 33, Aug. 13, 1927, pp. 1157-1163, 18 figs. Relation between nature of ore, volume of blast and dimensions of furnace; economic aspect of ore grinding; active reduction space of furnaces charged with coarse or with fine ore; equipment and modes of charging and charge distribution.

BOLTS

STRESSES. Effect of Initial Elastic Stresses on Strained Bolts (Der Einfluss der elastischen Vorspannung auf die Beanspruchung von Schrauben), G. Bersa. Dinglers polytechnisches Jl., vol. 342, no. 12, June 1927, pp. 133-136, 4 figs. Points out cases in which usually negligible initial elastic stresses in bolts and bolted parts may become important and cause overstress of bolt; derives formulas for calculation of such stresses and shows how they may be eliminated in some cases.

BRASS

FORGINGS. Brass Forging, O. J. Berger. Metal Industry (N. Y.), vol. 25, no. 8, Aug. 1927, pp. 321-323, 12 figs. Methods of manufacturing brass forgings and their advantages over castings.

FOUNDRY PRACTICE. The Fundamentals of Brass Foundry Practice, R. R. Clarke. Metal Industry (Lond.), vol. 31, no. 6, Aug. 12, 1927, pp. 123-125. Physical and chemical phases of founding; a discussion of the art and science of founding; prevention of warped castings and core-blows.

BRONZES

BEARING METAL. Bearing Metal Bronzes, H. J. Roast and F. Newell. Iron & Steel Can., vol. 10, no. 8, Aug. 1927, pp. 236-244, 35 figs. The essential constants of bronzes in every day use as determined by a series of tests with metals carried out under practical conditions.

CAST IRON

CARBON CONTENT, EFFECTS OF. Effect of Carbon Content on Properties of Cast Iron (Der Einfluss des Kohlenstoffes auf die Eigenschaften des Gusseisens), E. Diepschiag. Giesserei Zeitung, vol. 24, no. 15, Aug. 1, 1927, pp. 418-420. Modes of occurrence of carbon in pig iron castings, chemically interpreted; review of German and American work on carbon content effects.

FATIGUE. Tests of the Fatigue Strength of Cast Iron, H. F. Moore. Eng. Experiment Station—Unive. of Illinois Bul., vol. 24, no. 40, June 7, 1927, 47 pp., 26 figs. A report of an investigation conducted by the Engineering Experiment Station University of Illinois in cooperation with the Allis-Chalmers Manufacturing Company.

HEAT-TREATED. Heat-treated Cast Iron. Metallurgist (Supp. to Engr.), Aug. 1927, pp. 116-118, 3 figs. Comments on paper by Prof. Piwowarsky at Sheffield Conference of Inst. of Brit. Foundrymen, July 5-8, 1927.

HIGH DUTY. Effects of Nickel and Chromium on the Strength of Gray Cast Iron (Sur les effets du nickel et du chrome sur la resistance de la fonte grise), E. Piwowarsky. Fonderie Moderne, vol. 21, Aug. 10, 1927, pp. 243-250, 8 figs. Metallographic studies and mechanical tests showing that by accelerated cooling and by adding nickel, or nickel and chromium transverse strength may be increased 130 kg. per sq. mm. and tensile strength may be as high as 75 kg. per sq. mm. Brinell hardness 200 to 300.

PRODUCTION OF. Progress in the Production of High Duty Cast Iron, E. Piwowarsky. Foundry Trade Jl., vol. 36, no. 18, Aug. 18, 1927, pp. 147-151, 1 fig. Existing specifications; causes of uncertainty of facts; two solutions offered; low melting temperatures vs. superheating; theories developed by science of crystallization; metal poured with a mold with variously heated sections; conclusions drawn from investigations of heated mold sections; relation between melting temperatures, superheating and contraction; relation between chemical composition and superheating; relation between melting temperatures; superheating, and contraction; conclusions drawn from superheating experiments; jolting of molten iron; theories based on formation of graphite above critical temperature; hypothetical explanation; process of producing high-duty cast-iron.

NICKEL AND CHROMIUM IN. The Economic Value of Nickel and Chromium in Gray Iron Castings, D. M. Houston. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 17 pp., 11 figs. Importance of base composition as economic factor is dwelt upon at length, and illustrations are given of nickel-chromium mixtures developed with proper base composition whereby Brinell hardness was uniformly increased twenty to thirty

points without impairing machinability at approximately same cost per pound as plain cast iron.

SMELTING. Smelting Operation and Its Influence on Shrinkage, Expansion and Graphite Formation in Cast Iron (Der Schmelzbetrieb und seine Bedeutung für die Schwindung, Ausdehnung und Graphitbildung im Gusseisen), G. Krebs. Zeit. Für Die Gesamte Giessereipraxis, vol. 48, no. 30, July 24, 1927, pp. 265-267. Discusses low temperature vs. high temperature smelting, chemistry of graphite formation and general physical properties as function of smelting temperature.

STRENGTH OF. The Strength of Cast Iron, J. E. Fletcher. Foundry Trade Jl., vol. 36, no. 570, July 21, 1927, pp. 69-72. Paper presented at Sheffield Convention of the Institute of British Foundrymen.

TESTING. Principles of Testing, H. R. Pitt. Foundry Trade Jl., vol. 35, nos. 550 and 551, Mar. 3 and 10, 1927, pp. 193-194 and 213-215. Endeavors to formulate best methods of determining mechanical properties of cast iron and applying, as far as possible, recognized principles and methods of testing to measurement and assessment of its physical values; basic desiderata; theory of transverse testing. Mar. 10: Methods of expressing test results; transverse, fatigue, impact and hardness testing; shear.

TREATING. Improving the Quality of Gray Cast Iron (Amelioration des Qualites de la Fonte Grise). Fonderie Moderne, vol. 21, Aug. 10, 1927, pp. 257-262. Compilation on various physical and chemical methods of cast iron treating, including graphitization; Lanz method of making pearlitic cast iron, Corsalli and Dechesne methods, etc.; results of mechanical tests.

CASTING

CENTRIFUGAL. The Centrifugal Casting Process, J. D. Capron. Blast Furnace & Steel Plant, vol. 15, no. 8, Aug. 1927, pp. 376-381. Art of centrifugal casting is reviewed from 1809 to present; deLavaud process employed for casting pipe fully explained; other methods given brief mention.

CONTINUOUS. Continuous Casting of Small Parts. Iron Age, vol. 120, no. 7, Aug. 18, 1927, pp. 391-393, 5 figs. Production of nearly 10,000 castings for small electrical motors attained with minimum of labor, re-using sand each hour.

CASTINGS

STRESSES. Stresses in Non-Ferrous Castings, C. H. Desch. Foundry Trade Jl., vol. 36, no. 570, July 21, 1927, pp. 73-75, 4 figs. Shrinkage characteristics of various non-ferrous metals; from a paper read before the Sheffield Convention of the Institute of British Foundrymen. See also abstract in Brass World, vol. 23, no. 8, Aug. 1927, pp. 259-261, 3 figs.

CENTRIFUGAL CASTING

SHEET BARS. Centrifugal Casting of Sheet Bars. Iron & Coal Trades Rev., vol. 115, no. 3102, Aug. 12, 1927, p. 227, 2 figs. Some economic possibilities of the process described by Leon Cammen before the American Society for Steel Treating.

CHROMIUM PLATING

DEVELOPMENTS. Chromium Plating Developments, C. H. Proctor. Metal Industry (N. Y.), vol. 25, no. 8, Aug. 1927, pp. 331-333. Recent advances in the commercial electrodeposition of chromium. From the Monthly Review of the American Electro-Platers' Society.

INDUSTRIAL APPLICATIONS. Chromium Plating—A New Aid to Industry. Iron & Steel (Canada), vol. 10, no. 7, July 1927, pp. 207-209. Properties of chromium plating; applications.

COPPER

CANADA. Canadian Copper and Its Production, C. P. Browning. Can. Min. & Met. Bul., no. 184, Aug. 1927, pp. 944-972, 12 figs. Principal occurences in Canada; Bibliography; paper before Vancouver meeting of Empire Mining and Metallurgical Congress, Sept. 14, 1927.

HARDENED. Hardened Copper. Automotive Mfr., vol. 69, no. 5, Aug. 1927, p. 15. A recovered art; details of ancient cutting tools and the production of their hardened edges; actual hardness of commercial copper.

COPPER ALLOYS

HEAT TREATMENT. The Effect of Heat Treatment on Some Mechanical Properties of 85:15 Copper-Tin Alloy, R. J. Anderson. Am. Metal Market, vol. 34, no. 160, Aug. 18, 1927, pp. 3-6, 13 figs. Metallographic constitution of alloy; prior work on heat treatment of copper-tin alloys; method of investigation; results of tests; microscopic examination; copper-tin alloy; conclusions; bibliography.

CORROSION

PROTECTIVE FILM. Paradox of Corrosion and Protective Film Theory, T. Fujihara. Indus. & Eng. Chem., vol. 19, no. 9, Sept. 1927, pp. 1008-1009, 10 figs. These results show that protective film produced by corrosion after a certain time will reverse an original rate of corrosion of metals, thus bringing out a paradox that the more favorable the condition for corrosion the less would be the corrosion; evidently, this contradicts electrolytic theory, which claims that the pure metal corrodes less than the impure metal.

CRANES

ELECTRIC. All-Welded Electric Crane Embodies New Features of Design. Iron Trade Rev., vol. 81, no. 6, Aug. 11, 1927, pp. 316-318, 5 figs. Describes 10-ton, 60-ft. span electric overhead traveling crane constructed entirely by means of arc welding by Cleveland Crane & Eng. Co. See also Iron Age., vol. 120, no. 6, Aug. 11, 1927, pp. 330-331, 4 figs.

ELECTRIC FURNACES

AUXILIARY EQUIPMENT. Auxiliary Equipment for Electric Melting Furnaces, J. D. Keller. Fuels & Furnaces, vol. 5, no. 8, Aug. 1927, pp. 1011-1017, 14 figs. Dis-

cussion on apparatus employed for controlling arc furnaces and induction furnaces; electrical connections; electrode regulators; power limitators; reactors; transformers; generators.

BRASS MELTING. Development of Electric Brass Melting in the United States. Chem. Age, vol. 17, no. 423, Aug. 6, 1927, pp. 9-10. A history of the method and the economies effected.

FORGING AND HARDENING. Notes on the Use of Electric Power for Forging, Normalizing and Hardening Drill Steel Bits. S. African Inst. of Elec. Engrs.—Trans., vol. 18, May 1927, pp. 71-82. Discussion of a paper by E. D. Brunner.

HARDENING. The Hump Hardening Furnace. Mech. World, vol. 82, no. 2117, July 29, 1927, pp. 79-80, 2 figs. Description of a Leeds and Northrup electric hardening furnace.

HEAT TREATMENT. Electric Furnaces of Interesting Design Used in Heat Treatment of Gears, I. S. Wishoski. Fuels & Furnaces, vol. 5, no. 8, Aug. 1927, pp. 991-995, 3 figs. Electrically heated furnace of roller hearth type with heating elements above and below hearth, used in heat treating gears and pinions for automobile differentials; automatic electric furnace with vertical heating chamber used in heat treating ring gears.

HIGH-TEMPERATURE. Tungsten-Wound Furnaces for High Temperatures (Wolframspiralöfen für sehr hohe Temperaturen), W. Fehse. Zeit. für technische physik, no. 3, 1927, pp. 119-122, 5 figs. Describes number of different forms of furnaces designed for high-temperature operation, one being for service up to 2200 deg. cent. Details of design and constructional diagrams are given. Particular feature of furnaces is that they can be readily taken down for renewal of heating element.

IRON FOUNDRIES. Changing and alloy Melting of Steel with Electrical Furnaces (Über Einsatz-und Einschmelzarbeiten beim Lichtbogen-Elektrostahlofen), K. von Kerpely. Centralblatt der Hütten u. Walzwerke, vol. 31, no. 30, July 27, 1927, pp. 409-414. Discussion of processes and advice as to efficient operation of furnaces in producing alloy iron and steel.

LINING. Plastic Furnace Lining Gives Long Service. Power Plant Eng., vol. 31, no. 16, Aug. 15, 1927, pp. 870-872, 12 figs. Properly installed so that it is thoroughly pressed into uniform mass and properly vitrified it will last long periods under most severe firing.

ELECTRIC WELDING, ARC

STELLITE. Arc Welding of Stellite, C. M. Rusk. Welding Engr., vol. 12, no. 8, Aug. 1927, pp. 32-33, 6 figs. Great savings are shown in cement mills where grinding rings are reclaimed at low cost and long shutdowns averted.

ELECTRODEPOSITION

HYDROGEN-ION CONCENTRATIONS. The Importance of Hydrogen-Ion Concentrations in the Electro-Deposition of Metals, H. T. S. Britton. Indus. Chemist, vol. 3, no. 30, July 1927, pp. 314-318, 4 figs. Essential factors on which electrodeposition depends; necessity of careful regulation of hydrogen-ion concentrations of solutions from which base metals are to be deposited.

ELECTRODES

HEATING. A Study of Electrode Heating, J. B. Green. Am. Welding Soc.—Jl., vol. 6, no. 7, July 1927, pp. 22-29, 7 figs. Study of factors affecting electrode heating, with description of experimental work.

FORGE SHOPS

BILLINGS AND SPENCER. Billings and Spencer Forge Plant, C. Longenecker. Forging—Stamping—Heat Treating, vol. 13, no. 8, Aug. 1927, pp. 312-315, 4 figs. Description of one of pioneer companies in drop forge industry; construction of buildings and equipment in them is presented in detail.

DODGE. Dodge Forge and Heat Treating Plant, C. Longenecker. Blast Furnace & Steel Plant, vol. 15, no. 8, Aug. 1927, pp. 385-395, 11 figs. General description of plant; forge shop exemplifies latest practice in design and equipment; heat treating, cleaning, and pickling performed on large production.

WILLYS-OVERLAND. Willys-Overland Plant, J. N. Willys. Mfg. Industries, vol. 14, no. 2, Aug. 1927, pp. 91-94, 5 figs. Description of new shop and economies effected.

FORGING

SWAGE. Principles of Swage Forging (Die Grundlagen der Gesenkschmiede), J. Pitscheneder. Werkstattstechnik, vol. 21, no. 15, Aug. 1927, pp. 437-440, 17 figs. Brief history, presents and discusses instructions for efficient swage forging.

FURNACES

HEAT TREATING. Furnace Development in Heat Treating and Forging, W. M. Hepburn. Am. Soc. for Heat Treating—Preprint for 9th annual convention, Sept. 19 to 23, 1927, 14 pp., 7 figs. Scientific developments in furnace equipment are then related with particular reference to combustion, refractories, insulation, and temperature controls; some outstanding modern gas-fired installations embodying significant developments are described.

FURNACES, INDUSTRIAL

CONSTRUCTION. Binding for Industrial Furnaces, A. E. Perkins. Forging—Stamping—Heat Treating, vol. 13, no. 8, Aug. 1927, pp. 329-330, 1 fig. Author gives calculations required to provide necessary strength in binding of furnaces; relation of binding to furnace life.

GAGES

WEAR OF. Recent Experiments Relating to the Wear of Plug Gages, H. J. French and H. K. Herschman. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 26 pp., 11 figs. Results are given of tests made in laboratory wear tester in gaging file hard high carbon steel, aluminum "piston alloy" and cast iron; of various gage metals investigated chromium-plated gages showed highest resistance to wear under conditions of metal-to-metal contact; ammonia-treated chromium-aluminum steel, marketed under name Nitralloy, was second in resistance to wear and

much superior to remainder of group which showed variations but no radical differences in performance of individual metals.

IRON

ARMCO. Armco Ingot Iron, R. L. Kenyon. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 59 pp., 36 figs. Scope of paper includes description of material, its chemical analysis, its microstructure after various treatments and effect of mechanical work and heat treatment on its various physical properties; this data is given for Armco ingot iron in form of hot-rolled and cold-rolled bars and shapes, plates, sheets, and wire; tests reported include tension, compression, shearing, impact, hardness, and fatigue tests of various kinds.

CARBURIZATION. Carburizing Iron by Mixtures of Hydrogen and Methane, W. P. Sykes. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 19 pp., 25 figs. This paper describes determination of mixtures of hydrogen and natural gas (80 per cent methane) neutral to a steel of given carbon content at temperatures between 1470 and 2085 degrees Fahr. (800 and 1140 degrees Cent.); observed concentrations of CH in atmosphere correspond closely to theoretical values previously suggested by Le Chatelier.

DESULPHURIZING ACTION OF MANGANESE. Desulphurizing Action of Manganese in Iron, C. H. Herty, Jr. and J. M. Gaines. U. S. Bur. Mines—Reports of Investigations, no. 2817, July 1927, 8 pp. 2 figs. Relation between temperature and solubility product for MnS in iron in contact with solid MnS determined over range 1100-1440 deg. cent and 1 per cent Mn to 1.75 per cent Mn; effect of oxidization on desulphurization is discussed; desulphurizing action of manganese in transfer ladle is discussed.

DIRECT PRODUCTION. The Direct Production of Pure Iron, P. Longmuir. Am. Electro-chemical Soc.—Advance Copy, for meeting Apr., 28, 29 and 30, 1927, pp. 695-705. Author's experience is such as to lead him to pessimistic rather than optimistic view as to commercial possibilities of direct reduction; Thomas Rowlands process, however, offers decided advantages over other older processes: The primary advantage is in direction of recovery of whole of iron present in ore in state of metallic purity; main stages of Rowlands process are: Distillation of coal; preliminary reduction of iron ore; complete reduction of iron ore; magnetic separation of pure metallic iron; revival of spent gases; iron produced forms excellent foundation material for production of the very highest class of straight carbon and alloy steels.

MICROSTRUCTURE. Some Unusual Microstructures in Iron, F. S. Tritton. Metallurgist (supp. to Engineer), June 24, 1927, pp. 88-90, 6 figs. Unusual microstructures described have been observed in specimens of iron during course of metallurgical research in a modern laboratory, and illustrate that iron still exhibits some phenomena that are not well known or understood.

IRON ALLOYS

IRON-NICKEL. On the Determination of the Heterogeneous Field in the Iron-Nickel System, K. Honda and S. Muira. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 11 pp., 6 figs. By means of dilatometric analysis, heterogeneous field in iron-nickel alloys was determined; by application of law of depression of freezing point, lowering of A_3 point of iron by addition of nickel to iron was calculated and found to agree with observed data; lastly variation of coefficient of expansion with concentration in iron-nickel system was discussed in light of structural change of system.

MANGANESE. Alloys of Iron and Manganese Containing Low Carbon, R. Hadfield. Foundry Trade Jl., vol. 36, no. 18, Aug. 18, 1927, pp. 157-158. Comparison of two types of alloys of iron and manganese, one with carbon varying from about 0.50 to 1.20 per cent and the other with little or no carbon, 0.08 to 0.20 per cent.

NICKEL CAST IRON. Alloy Cast Iron Meets High Duty Requirements. Am. Metal Market, vol. 34, no. 160, Aug. 18, 1927, p. 7, 4 figs. By use of nickel, or nickel and chromium in proper ratio, following improvements may be obtained: 1. Increased strength; 2. greater toughness; 3. uniformity increased hardness with better machinability; 4. reduction in chill; 5. increased wear resistance.

IRON AND STEEL

EFFECT OF TORSION AND BENDING ON. The Effect of Torsion and Bending on Soft Steel. Metallurgist (Supp. to Engineer), July 1927, pp. 107-109. Report of a series of experiments on commercial iron by Brenward Garre, described in Korrosion und Metallschutz, Jan. 1927.

ELECTRICAL AND THERMAL CONDUCTIVITY. On the Electrical and Thermal Conductivities of Carbon Steel and Cast Iron, H. Masumoto. Tohuku Imperial University—Science Reports, vol. 16, no. 4, May 1927, pp. 417-435, 4 figs. Develops, on basis of original research, empirical formulas for effect of impurities on specific resistance and heat conductivity of cast iron and carbon steels.

GASES IN. Gases in Molten Iron and Steel. Metallurgist (Supp. to Engineer), June 1927, p. 87. Method of determining gas contained in a known volume of molten iron or steel, intended primarily for work on a small laboratory scale; masses of metal used varying from 150 to 90 grams.

METALLOGRAPHY. Deep Etch Test For Iron and Steel, H. G. Keshian. Am. Soc. for Steel Treating—Preprint for 9th annual convention, Sept. 19 to 23, 1923, 37 pp., 30 figs. This paper deals with discussion of deep etch test for iron and steel and describes types of structure revealed by method; it discusses factors influencing results, such as method of melting, chemical composition, reduction of area, heat treatment, direction of fiber in steel, etc; points out value and limitations of method based on relation of various etch structures to performance of steel in service as observed by author.

PROPERTIES AT HIGH TEMPERATURES. Armco Iron and Mild Steel at High Temperatures. Engineering, vol. 124, no. 3212, Aug. 5, 1927, pp. 181-182, 12 figs. From Special Report No. 1, Dept. of

Scientific and Industrial Research, Engineering Research, covering armco iron and 0.17 and 0.24 carbon steel.

SPRINGS

HAIRSPRINGS. The Manufacture of Hairsprings, H. Moore and S. Beckinsale. Forging—Stamping—Heat Treating, vol. 13, no. 8, Aug. 1927, pp. 292-294 and 305. Heat-treating methods and their effect on properties of springs receive much consideration; comparison is made between springs of steel and non-ferrous metals.

STANDARDS

GERMAN N. D. I. REPORT. Report of the German Industrial Standards Committee (DIN-Mitteilungen). Maschinenbau, vol. 6, no. 14, July 21, 1927, pp. 730-731. Proposed standards for rail sections, fish plates and wire nails of mine rail tracks.

STEEL

ACID. Qualitative and Economic Significance of Acid Crucible Steel, Particularly Acid Electric Steel (Die qualitative und wirtschaftliche Bedeutung des sauren Stahlgusses, insbesondere des sauren Elektrogusses), V. Zsak. Giesserei Zeitung, vol. 24, no. 15, Aug. 1, 1927, pp. 413-417, 4 figs. Historical review and description of acid and basic processes of steel making; use of converter, acid martin and acid electric furnaces in foundry; chemical analyses and mechanical tests of acid Siemens-Martin and acid electric steels; acid furnaces more economic than basic if 0.075% phosphorus content be permitted.

ANNEALING. The Annealing of Mild Steel Sheets, C. A. Edwards and J. C. Jones. Forging—Stamping—Heat Treating, vol. 13, no. 8, Aug. 1927, pp. 316-319. Investigation discloses influence of temperature on properties, as determined by Erichsen test, of sheets of varying thickness. See also Blast Furnace & Steel Plant, vol. 15, no. 8, Aug. 1927, pp. 396-399.

CADMIUM PLATING. Cadmium Plating Resists Rust, C. H. Humphries. Iron Age, vol. 120, no. 7, Aug. 18, 1927, pp. 401-402, 1 fig. Addition agents in electrolytic bath give mirror-like deposit of good throwing power.

CARBON IN. Factors Affecting Total Carbon in Steel. Iron Age, vol. 120, no. 9, Sept. 1, 1927, p. 535. Important results from study of six German blast furnaces; silicon content and crucible temperatures affect carbon content.

CASE HARDENING. Case Hardening of Steel by Means of Chloride of Silica (La cementation du per par le chlorure de silicium), M. A. Sanfourche. Metallurgie et la Construction Mecanique, no. 32, Aug. 11, 1927, p. 19. Two series of experiments steel was hardened to depth of 0.3 to 2.7 cm. after ½ to 3 hours treatment with chloride of silica at temperatures ranging from 900 deg. cent. to 1150 deg. cent.

DETERIORATION OF. Deterioration of Structural Steels in the Synthesis of Ammonia, J. S. Vanick. Am. Soc. for Steel Treat.—Trans., vol. 12, no. 2, Aug. 1927, pp. 169-189 and (discussion) 189-194, 11 figs. Explanation of mechanism of deterioration of steels is advanced; from facts that oxides are reduced, carbides are decomposed, and nitrides formed in chromium steels after slight decarburization has been achieved, explanation of mechanism of deterioration is advanced which regards ammonia as active corrosive, and metal as porous filter which permits ammonia enrichment to destructive concentration.

DIRECT FROM ORE. The Manufacture of Steel in "One Process" Direct from Ore, O. Smalley and F. Hodson. Am. Electrochem. Soc.—Advance Copy, for meeting Apr. 28, 29, and 30, 1927, pp. 706-723, 4 figs. Description of the Pehrson-Prentice and "Carsil" processes.

ELASTIC HYSTERESIS. Elastic Hysteresis. Metallurgist (Supp. to Engineer), July 1927, pp. 105-107, 4 figs. Abstract of a paper in Rev. de Met. for Dec. 1926.

FATIGUE TESTS. Fatigue Tests of Carburized Steel, H. F. Moore and N. J. Alleman. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 14 pp., 12 figs. Three steels were studied; a plain carbon steel, nickel steel, and chromium-nickel steel; several different treatments were tried for each steel; in general, test results suggest that carburizing, followed by suitable heat treatment, is promising means of increasing fatigue strength of steel as well as effective means of increasing surface hardness; steel quenched in oil from carburizing pot showed more increase in fatigue strength than did steel cooled in carburizing pot.

FLAWS IN. Flaws appearing in Working of Iron and Steel, Their Causes and Ways of Avoiding Them, (Bei der Verarbeitung von Eisen und Stahl zutage tretende Fehler, ihre Ursachen und Vermeidung), Anton Pomp. Maschinenbau, vol. 6, no. 14, July 21, 1927, pp. 689-696, 30 figs. Metallographic studies and strength tests of effects of overheating in annealing and hardening, of blistering in pickling, and of overrolling.

FRACTURES. Studies Internal Fractures in Bars, E. F. Davis and R. J. Peters. Iron Age, vol. 120, no. 7, Aug. 18, 1927, pp. 400-401, 2 figs. Sulphur prints indicate cause in an impure streak inherited from segregation in ingot top.

HIGH TEMPERATURES, EFFECT OF. Properties of Steel at High Superheat Temperatures, A. McCance. Mech. World, vol. 81, no. 2111 and 2113, June 17 and July 1, 1927, pp. 434-435 and 5-6, 11 figs. Examination of temperature-strength curves for various steels; secondary effects of prolonged high temperature.

METALLURGY. The Melting or Molten Stage of Steel Manufacture With Particular Reference to the Deoxidizing, Refining and Contamination Phases, G. A. Dornin. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 6 pp. Bad effects of oxides in steel and points to only known methods for their removal from molten bath; various steel melting processes and their possibilities for good steel making as shown by their capacity to make steel free or relatively free from oxides.

NITRATION. Nitration of Steel and its Industrial Use (La Nitruration des Aciers et son utilisation industrielle), L. Guillet. Genie Civil, vol. 91, nos. 2, 3, and 4, July 9, 16, and 23, 1927, pp. 38-43, 60-63, and 86-89, 29 figs. The Krupp process applied to nickel steel, chrome steel, and other steels.

PIPING IN INGOTS. The Control of Piping in Steel Ingots, W. S. Wilson. Iron & Steel Can., vol. 10, no. 8, Aug. 1927, pp. 231-233 and 235, 13 figs. Cause of piping; narrow-tipped ingot mold practice; charging ingots hot; casting large and up; bottom pouring; sink heads; Hadfield process; fluid compression; blow holes.

WORLD EXPORTS. Finished Steel in World Exports, P. M. Tyler. Iron Age, vol. 120, no. 9, Sept. 1, 1927, pp. 536-537 and 597-599. Gains in bars, wire and tin plate tend to offset heavy tonnage losses in rails, shapes and pig iron; sheet products from backbone of American trade.

STEEL AND IRON

CONSTITUTION OF. The Constitution of Steel and Cast Iron, F. T. Sisco. Am. Soc. for Steel Treat.—Trans., vol. 12, no. 2, Aug. 1927, pp. 279-290, 3 figs. Present installment, tenth of series, discusses effect of four common elements, silicon, sulphur, phosphorus and manganese on the iron-carbon alloys containing 2.00 per cent or more carbon—(the cast irons); each element is discussed under two heads; first, amount of element in cast iron and how the percentage is controlled; and second, effect of the element on the constitutional changes, microstructure and properties.

STEEL CASTINGS

LARGE, MANUFACTURE OF. Manufacture of a Large Steel Casting (La Fabrication D'Une Grande Piece En Acier Coule), F. A. Melmoth and T. H. Brown. Revue de Fonderie Moderne, vol. 21, July 25, 1927, pp. 221-231, 12 figs. Full description of process of casting support of propeller shaft, from first tests of casting, critical discussion of used metallurgical and molding methods and their alternatives.

STEEL FOUNDRIES

ELECTRIC. Preheating Reduces Melting Period, E. Bremer. Foundry, vol. 55, no. 16, Aug. 15, 1927, pp. 626-630 and 642, 7 figs. Description of Burnside Steel Foundry Co., Chicago, Ill.

STEEL, HEAT TREATMENT OF

BALL-BEARING STEEL. Heat Treatment of Two Ball Bearing Steels, B. Kjerrman. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 20 pp., 8 figs. This paper gives results of electrical resistance tests on two ball bearing steels, one of common type, the other with higher content of chromium and the addition of molybdenum.

DEFINITION OF TERMS. Terms Relating to Heat Treatment. Forging—Stamping—Heat Treating, vol. 13, no. 8, Aug. 1927, pp. 300-301. Definitions are result of labors of committees, appointed by three societies, for purpose of clarifying terms whose meaning was uncertain.

DESIGN AND. Design From the Heat Treating Standpoint, G. M. Eaton. Am. Soc. for Steel Treating—Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 19 pp., 7 figs. The author stresses need for close co-operation between metallurgist and the mechanical engineer.

FURNACES AND METHODS. Modern Furnaces and Heat Treating Methods, E. F. Davis. Am. Soc. for Steel Treat.—Trans., vol. 12, no. 2, Aug. 1927, pp. 291-302. Author of this paper describes and discusses in a practical way the various methods which are in use in many manufactories in the heating of steel parts for forging, hardening and tempering; he makes a plea for a more thorough study of problems of average heat treatment departments whereby these departments may be provided with more efficient heating equipment; comparison is made of type of high production machining equipment which is provided for most machine shops in contrast to antiquated inefficient heating equipment found in many of the so-called modern plants; a discussion of the merits of the different methods and types of furnaces used in heating metal parts is dealt with at length.

FUTURE OF. Heat Treatment is Adding Steadily to the Effective Service of Steel and Non-Ferrous Metals—Greater Things Just Ahead. Iron Age, vol 120, no. 10, Sept. 8, 1927, pp. 609-620. Various opinions as to the future of heat treatment.

HARDENING. Hardening by Reheating After Cold Working, M. A. Grossmann and C. C. Snyder. Am. Soc. for Steel Treating —Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 16 pp., 18 figs. Authors advance theory which explains phenomenon of hardening of cold worked steel by reheating of low temperatures; attention is called to certain significanct features observed under microscope, and other evidence is offered pointing to simple reason for observed changes in strength, hardness and ductility; effects of reheating after quenching as well as cold working are discussed in detail, and their different natures are set forth.

HARDENING. The Hump Method of Hardening. Automobile Engr., vol. 17, no. 231, Aug. 1927, pp. 304-305, 3 figs. An interesting electric furnace for obtaining uniform results.

QUENCHING. Oils as Quenching Media for Steels. Forging—Stamping—Heat Treating, vol. 13, no. 8, Aug. 1927, p. 326. Discussion of use of vegetable and mineral oils with slight reference to properties imparted by air.

QUENCHING. What Happens When High Speed Steel is Quenched, B. H. De Long and F. R. Palmer. Am. Soc. for Steel Treating —Preprint for 9th Annual Convention, Sept. 19 to 23, 1927, 11 pp., 11 figs. This paper deals with metallography of high speed steel when tempered at 1100 deg. Fahr. after cooling during quenching to varying temperatures below 1300 deg. Fahr.; authors make following observations: High speed tools tempered at 1100 deg. Fahr. before being allowed to become sufficiently cold in quench are brittle due to mixed structures; straightening of high speed tools may be readily carried out during quenching at temperatures between approximately 1300 and 700 deg. Fahr.; method is indicated for determining

whether high speed tools have been quenched to sufficiently low temperature before tempering.

PITFALLS IN. Pitfalls in Heat Treatment, J. W. Urquhart. Machy. (Lond.), vol. 30, no. 776, Aug. 25, 1927, pp. 658-659. Cracking; source of undisclosed cracking in steel; tempering the hardened zone; difficulties with non-uniformity of section.

RATE OF COOLING. Influence of Rate of Cooling on the Structure of Alloys (Uber den Einfluss der Abkühlungsgeschwindigkeit auf die Struktur der Legierungen), A. A. Botschwar. Zeit. für anorganische u. allegemeine Chemie, vol. 134, no. 1-3, July 26, 1927, pp. 189-194, 1 fig. A metallographic study of steels containing carbon, manganese, silicon, sulphur and phosphorus.

SELECTION OF EQUIPMENT. Selecting Electric Heat-Treating Equipment, E. Fleischmann. Machy. (N. Y.), vol. 34, no. 1, Sept. 1927, pp. 66-70, 7 figs. First of two articles explaining various points to be considered in planning installations.

THERMAL STRESSES. Thermal Stresses in the Cooling of Large Castings, with Reference to Treatment of Large Solid-Cylinder Forgings, (Wärmespannungen beim Abkühlen grosser Güsse bzw. beim Vergüten grosser Schmiedestücke im Form von Vollzylindern), E. Maurer. Stahl u. Eisen, vol. 47, no. 32, Aug. 11, 1927, pp. 1323-1327. A theoretical conservative analysis giving values which seem to be exceeded in practice; influence of tempering and bearing of elastic limits on tempering temperatures.

STEEL, HIGH-SPEED

CUTTING TOOLS. Heat Treating is Critical Operation in Making Cutters and Tools, F. W. England, Iron Trade Rev., vol. 81, no. 5, Aug. 4, 1927, pp. 251-253, 4 figs. Describes high-speed steel hardening furnaces in plant of Illinois Tool Works, Inc.; laboratories equipped for chemical, metallurgical, microscopic, and screen projection tests.

FAULTY HARDENING OF. Faulty Hardening of High-speed Steel, E. Hundremont and H. Kallen. Eng. Progress, vol. 8, no. 8, Aug. 1927, pp. 199-200, 5 figs. Some examples of some faultily hardened high-speed steel parts.

STEEL INDUSTRY

FRANCE. Iron and Steel Centers in France, A. J. Reynaud. Iron age, vol. 120, no. 9, Sept. 1, 1927, pp. 540-542. What are the conflicting factors which have governed development of the various districts.

STEEL WORKS

ELECTRIFICATION. An Extensively Electrified Steel Plant, M. T. Lothrop. Elec. Wld., vol. 90, no. 5, July 30, 1927, pp. 207-210, 7 figs. Installation of larger electric arc furnaces and use of all-electric charging equipment, cranes and blooming mill increase efficiency and production; roller bearings widely used.

SHEET BARS. Changing Mills with Minimum Delay. Iron Age., vol. 120, no. 7, Aug. 18, 1927, pp. 394-396, 6 figs. Careful preparation of an operating schedule and a construction program enabled the Inland Steel Co. to switch from an existing 24-in. three-high mill to a new 19-in. continuous sheet bar mill with an interruption of only 12 days in production.

STEELS

HEAT RESISTING. Heat-Resisting and Non-Corrodible Steels. Instn. of Aeronautical Engrs.—Jl., vol. 1, no. 8, Aug. 1927, pp. 5-44, 17 figs. Present paper is concerned with the products resulting from research carried out by Messrs. Hadfield, Ltd., of Sheffield, and by our French confreres, Messrs. Commentry Fourchambault et Decazeville, of Imphy, in whose laboratories were carried out the researches of the well-known metallurgists, Dumas, Guillaume, Chevenard, Muguet, Fayol and Girin.

LOCOMOTIVE FORGINGS, FOR. Locomotive Forging Steels, O. V. Greene. Am. Soc. for Steel Treating—Preprint for 9th annual Convention, Sept. 19 to 23, 1927, 16 pp., 18 figs. The author gives results of tests made on various types of heat treated alloy steels for reciprocating locomotive parts.

SUBMARINES

STEEL FOR. Submarines Require Finest of Steel, H. R. Simonds. Iron Trade Rev., vol. 81, no. 6, Aug. 11, 1927, pp. 311-314, 8 figs. General discussion of use of steel for submarine construction; requirements of steel for various parts.

TIN PLATE

TIN-IRON ALLOY IN. The Tin-Iron Alloy in Tin Plate, E. F. Korman. Metal Industry (Lond.), vol. 31, no. 6, Aug. 12, 1927, pp. 130-132. The alloy as a spongy net work; effect of varying amounts of alloys; comparison of tinned and untinned cans; discussion of results; charcoal plate service.

TRANSFORMERS

ELECTRIC FURNACE TRANSFORMERS. Transformers for Electric Furnaces (Transformatoren für Elektroöfen), A. Höpp. Centralblatt der Hütten u. Walzwerke, vol. 31, no. 26, June 29, 1927, pp. 351-354, 3 figs. Specifications as to simplicity of construction and resistance to overloading, short circuits, dirt, etc.; discussion of construction of secondary windings; characteristics of Elin A. G. oil cooled, single-phase furnace transformer.

WELDING

ALUMINUM SHEET. Welding Pure Aluminum Sheet, T. C. Fetherston. Am. Welding Soc.—Jl., vol. 6, no. 7, July 1927, pp. 29-36, 9 figs. Importance of selecting material of good welding quality, using welding rods and flux of proper composition and quality, etc.

ATOMIC HYDROGEN. New Equipment Developed for Atomic Hydrogen Welding. Auto. Industries, vol. 57, no. 7, Aug. 13, 1927, p. 237, 2 figs. Principle of operation same as in design previously announced by General Electric Co., but mechanical and electrical features are improved; three units in outfit.

MACHINE FRAMES. Building Large Machine Frames in One Piece by Welding, R. E. Kinkead. Am. Mach., vol. 67, no. 7, Aug. 18, 1927, pp. 259-260, 2 figs. Substitution of welded steel for cast-iron frames.

News of the Chapters

STANDING OF THE CHAPTERS

During the month of August there were 93 new and reinstated members, while 105 were lost through arrears, resignations, and deaths, leaving a net loss for the month of 12 members. This is the second consecutive month in two years when the Society has not shown a gain in membership. The total membership of the Society on September 1, 1927, was 4,653.

In the following tabulation there appears the relative membership standing of the 32 chapters and 3 groups of the Society as of September 1, 1927.

GROUP I		GROUP II		GROUP III	
1. Detroit	484	1. Dayton	126	1. Tri City	81
2. Chicago	405	2. Hartford	124	2. Los Angeles	78
3. Pittsburgh	335	3. Milwaukee	122	3. New Haven	77
4. Philadelphia	332	4. Lehigh Valley	114	4. Washington	69
5. Cleveland	314	5. Canton-Mass.	108	5. Worcester	65
6. New York	280	6. Golden Gate	107	6. Southern Tier	62
7. Boston	244	7. Indianapolis	93	7. Rochester	61
		8. Cincinnati	92	8. Rockford	59
		9. Syracuse	87	9. Columbus	57
		10. St. Louis	83	10. Toronto	55
		11. Montreal	67	11. Providence	54
		12. Buffalo	64	12. Schenectady	40
		13. North West	52	13. Fort Wayne	37
				14. Springfield	32
				15. Notre Dame	24

GROUP I—Detroit and Chicago still retain positions 1 and 2. Philadelphia because of a net loss of 8 gave up position No. 3 to Pittsburgh which has a lead of 3 members. Only two chapters in this group showed gains, Detroit 1 and New York 6. The others had losses.

GROUP II—Welcome to position No. 1 Mr. Dayton!—you have done a splendid piece of work in climbing from No. 13 in this group to the top. Let's hope that you are not going to be satisfied to stay in Group II. Hartford, Milwaukee and Lehigh Valley who have been hovering around the top for some time have a little friendly competition with the refrigerating city. The only other change in this group was the advance of Indianapolis from position 8 to 7.

GROUP III—Tri City again heads the list with 81, having had a gain of 2 over the previous month. Los Angeles advanced from No. 3 to 2, shoving New Haven into No. 3. Rochester advanced from 9th to 7th place. while Columbus progressed from No. 10 to 9, Toronto going from 8th to 10th. The other chapters remain in the same positions.

The largest individual gain of any chapter in all of the groups goes to New York with an increase of 6; Golden Gate is second with a net increase of 4.

BOSTON CHAPTER

The eighth annual outing of the Boston Chapter was held at the Riverside Recreation Grounds, Auburndale, on Saturday, September 10, 1927, some 75 members attending. The field sports were run off between 2 and 3 p. m. and were won by Les Hawkridge, Herb Briggs, Bob Johnston, A. Bach, Tom Demar, and J. L. Magini. No running time was taken in these events but by the appearance of the winners and the time taken to recuperate it must have been faster than their usual average.

Vic Homerberg's collegians won the baseball game and Bob Johnston's steel handlers won the tug-of-war, each of whom divided the spoils with their opponents. E. B. Ashworth and A. D. Bach captured the canoe tilting honors after several casualties and Bach and Briggs won the 50 yard swimming race. Charlie Karle and Looie Zurbach excelled in quoits.

George Davis figured quite extensively in the day's program. He won second prize in the fat men's race, developed cramps in the 50 yard swimming elimination and assisted the magician during the evening's entertainment. The dinner was held up for some time due to the intrusion of a Chelsea Jew named M. Fitzgerald, who accused George of taking his daughter out for a joy ride on Labor Day evening. Only the timely arrival of a Massachusetts State Trooper saved George from bodily harm, as the majority of those present took sides with Fitzgerald. One of the attendants said he had seen Fitzgerald hanging around the grounds during the afternoon, so he was arrested and booked on a previous charge of blackmail.

At 6:00 p. m. one of Seiler's famous dinners consisting of clam chowder, tenderloin roast, chicken salad and ice cream was served and together with jazz by some of Harry Parker's musical friends and songs by Miss Irene Langley, also one of Harry's friends, kept the gang busy until the evening's vaudeville entertainment began.

The outing was a decided success and it is to be regretted that a large number of members were unable to attend. Thanks are due the Program Committee consisting of Dr. R. S. Williams, A. D. Bach, Walter Kunkel and Stanley Parker, and those who assisted them, for their able management of the program. Thanks are also due to Dr. Waterhouse who judged the field events and awarded the prizes, and to Earl Downing who umpired the ball game and assisted the collegians to win.

During the dinner Chairman Hawkridge announced that the special car to the Detroit Convention was practically filled up and that all plans have been completed for the Boston Chapter Metallurgical Course to start on October 7th at the Massachusetts Institute of Technology. *H. E. Handy.*

The following is an outline of a course on the principles of the metallurgy of iron and steel, metallography and physical testing to be given to the members of the American Society for Steel Treating under the auspices of Massachusetts Institute of Technology and the Boston Chapter of the American Society for Steel Treating from October 7 to March 30, 1928.

The Educational Committee of the Local Chapter, through its Chairman, V. O. Homerberg has presented to President Stratton of the M. I. T.,

a tentative outline of a lecture course to be given one evening a week for a period of 24 weeks beginning October 7, 1927. Dr. Stratton has expressed himself as highly in favor of this scheme of instruction and he has placed the facilities of M. I. T., together with the members of the instructing staff who are directly interested, at the disposal of the Boston Chapter.

It is planned to give these lectures on Friday evenings beginning at 7:45 p. m., each lecture to last for one hour, to be followed by a half hour of discussion. A tentative outline of the lectures, together with the names of the lecturers, follows. The attendance will be limited to members of the A. S. S. T., except on the occasion of the regular monthly meetings of the Chapter. Speakers will be chosen for the regular Chapter meetings to fit into the course as outlined.

A charge of $10.00 per member will be required to defray the incidental expenses of the Course.

The course will be divided into four main classes—General Metallurgy of Iron and Steel, with eleven classes from October 7 to December 16 with Dr. G. B. Waterhouse as lecturer. Testing of Metals, with four classes from January 6 to January 27 with Prof. I. H. Cowdrey as lecturer. Metallography, with eight classes from February 3 to March 23, with Dr. R. S. Williams as lecturer. Macroscopic Examination of Metals, with three classes from March 30 to May 4, with Dr. V. O. Homerberg as lecturer. The last two lectures on April 6 and May 4 are regular Boston chapter meeting nights.

The Boston chapter is to be congratulated upon this splendid activity and the members of the chapter should benefit greatly from this course of lectures under the guidance of such able men who are giving the lectures.

CLEVELAND CHAPTER

The first regular meeting of Cleveland Chapter was held in the Engineering Society rooms in Carnegie Hall, September 16, 1927. Considering that the date was so near that of the Detroit Convention it was exceptionally well attended. About twenty-five members were at the dinner and about eighty attended the meeting.

The preliminary run of moving pictures taken at the outing held at Cedarhurst Country Club June 29 was of great interest, especially to the ones who were present at this outing as they saw how they appeared on the silver screen.

Reports of the chairmen were heard and approved.

The speaker of the evening was Mr. O. G. Simmons, president and general manager of the National Tool Company, Cleveland. In his talk, illustrated by slides and moving pictures, he described methods of gear cutting and grinding gear teeth. One of the points which was stressed was that steels were continuously changing and some steel and heat treatment were needed to produce a material which would become fixed so that it could be accurately finished.

Only one such material so far has been discovered—a tungsten alloy which can now be ground accurately. The point reached was that equipment is available to grind accurately but the materials themselves were

not to be had which could be so ground. The speaker brought out the point that there was a big field for steel treaters to develop a commercial steel and a method of treating which would fix it in a permanent state so that it could be ground to the accuracy of the equipment.

Another feature of the talk was the fact that the accurate finished gear had far greater strength and entire freedom from noise. The discussion which followed was decided proof of the manner in which this interesting and instructive paper was received. *J. S. Ayling.*

DETROIT CHAPTER

The offering of evening courses in metallurgy by the College of the City of Detroit and the Cass Technical High School places the Detroit Chapter of the American Society for Steel Treating in a very fortunate position. Instead of finding it necessary, as many of our chapters do, to give courses in metallurgy, the Detroit Chapter has only to lend its support to the work being done by the above institutions. The members of the Detroit Chapter can not only show their appreciation of the work being done by the College of the City of Detroit and the Cass Technical High School, but can also help to stimulate interest in metallurgical work, by bringing these opportunities for instruction in metallurgy to the attention of men who should take advantage of them.

The College of the City of Detroit is offering in its Evening School a three-hour course in Metallurgy and Structure and Properties of Metals, while the Cass Technical High School is offering in its Evening School two courses in metallurgy, Metallurgy I and Metallurgy II, the latter being a continuation of Course I.

FORT WAYNE GROUP

The regular monthly meeting of the Fort Wayne Group of the American Society for Steel Treating was held at the Y. M. C. A. on Thursday, September 15. The meeting was opened with a dinner at 6:30 p. m.

W. E. McGahey, chairman, acted as Toastmaster, and the dinner was attended by 70 members and guests. During the dinner the Bowser Girls' Glee Club entertained the members and guests with songs and music. Following the dinner the girls entertained with an interesting program.

After the entertainment the speaker, A. H. d'Arcambal, sales manager of Pratt & Whitney Company, Hartford, Conn., was introduced.

Mr. d'Arcambel gave a very interesting and instructive talk on "Metal Cutting Tools." The speaker dwelled on three important factors in the making of good small tools; 1. The design of the tool, 2. The quality of the steel used, 3. The hardening of the tools.

The speaker illustrated his talk by samples of various kinds of tools, such as reamers, milling cutters, taps, etc., bringing out the importance of the proper design in the depth of flutes, size of the arbor holes in relation to the size of milling cutter, illustrating the development of the milling cutters from their early stage back in 1898 when milling cutters had a very small arbor hole and small teeth, up to the present time when the arbor hole is much larger and the teeth heavier and stronger. Also the method of fasten-

ing the cutters into the body was brought out by the speaker very forcefully.

Mr. d'Arcambal also explained that different kinds of tools must have different kinds of steel in their makeup. At the present time his company uses twelve different kinds of steel for the various kinds of tools and gages which they manufacture and the proper selection of the right kind of steel for the tools is the second very important factor in the making of tools.

The speaker brought out that the proper place to spend money to improve tools is in the hardening room and the Pratt and Whitney Company has realized this to its fullest extent. Invariably we find, the hardening room in most manufacturing plants, in a very dark and unsightly corner in the far end of the shop. The Pratt and Whitney Company realizes that the hardening room is the heart of their industry. Their hardening room is painted white, so as to make the surroundings clean and cheerful. All the furnaces are automatically controlled by electrical control equipment. The lead baths are also electrically heated, controlled within plus or minus five degrees. The temperature of all the quenching baths are also electrically controlled to within plus or minus five degrees.

Mr. d'Arcambal showed a number of slides illustrating the laboratory and hardening room in the Pratt and Whitney Company, also several slides were shown on the Wasp Aircraft Motor, manufactured by the Pratt and Whitney Company. The speaker brought out the fact that during the war it was necessary to overhaul the airplane motor after it had flown 50 hours, while with the new Wasp motor an airplane can fly 350 continuous hours without need of overhauling the motor.

The meeting closed with a discussion on small tools and gages and the members took the opportunity of looking over the various samples which the speaker had brought with him. *John A. Hansen.*

GOLDEN GATE CHAPTER

The executive committee of Golden Gate Chapter, A. S. S. T. were in session some two and a half hours August 17th. An abstract of their deliberations is here set forth for the benefit of those who may be interested.

PROGRAM. S. C. Alexander, vice chairman, has arranged an interesting and instructive program for the regular meetings which will be held as in the past, on opposite sides of the Bay on alternate months—one meeting with plant inspection will be held at the Caterpillar Tractor Co.'s establishment at San Leandro, while another visit to Stanford University is planned early in the coming year. Dr. Crook and Professor Arthur Domonoske, two charter and estimable members of the chapter, will conduct the Stanford meeting.

The first regular meeting will be held Wednesday, September 14, in San Francisco. One topic will be "Manufacture and Heat Treatment of Gears" by F. A. Brooks, Engineer of the Johnson Gear Company. Another subject discussed will be "Welds and Welding, recent developments, properties and structures" by W. F. Barron, Technical Service Engineer of the Linde Air Products Company. After the two principal speakers, short discussions

on three interesting topics will be undertaken by Messrs. Wise, Moody and Fess.

SACRAMENTO GROUP. The chapter has had in mind for over a year a plan for the establishment of a group at Sacramento. It was the consensus of opinion that the time is now ripe for the formation of this auxiliary and H. D. Grubb of the Pacific Scientific Co. was authorized and requested to cooperate with Messrs. Venter and Dolensky to the end that a speedy and satisfactory organization would result.

The committee also voiced its approval of the policy to send speakers to Sacramento from time to time if the auxiliary should so elect. The suggestion was offered that the Sacramento unit not be formed however, until after the regular September meeting so an announcment could be made at that time, it being surmised that such an announcement would be the means of drawing a number of auto parties to the capital city to witness the formation of this proposed unit. Mr. George Batton of Ludlum Steel offered to ''chiffonier'' the following gentlemen who were designated as an official installing committee to represent the Chapter—Messrs. Drake, Alexander, Wise, Grubb, Taylor and his niblets, the ''chiffonier''. Also —all others who would like to attend.

EDUCATIONAL. H. S. Taylor, metallurgical consultant par excellent, chairman of the educational committee, was able to state that an elementary course in metallurgy would soon be announced. The course will be given on the East side of the Bay. It will follow rather closely the preceding ones in its scope, and it is expected that a start will be made in the early autumn. The fact has long been recognized by the better informed members of the section, that a laboratory course of instruction in metallurgical manipulations was essential, if the Bay industries were to keep abreast with modern production methods.

There were, however, many difficulties to be overcome before such a laboratory could be established, such as—lack of a permanent place to house the equipment, scarcity of competent instructors, distance of travel for those seeking instructions, finance, etc. Many of these difficulties have been overcome, and it is confidently expected that by the first of the year the chapter will be able to offer a limited amount of laboratory instruction.

In the matter of location, Mr. Cecil Hawley and our good friend Phil Eastwood of the American Forge Co. have offered the use of a room which can be equipped to accommodate perhaps 10 students. Dr. Crook, Messrs. Taylor, Fess and Moody will, without a doubt, supervise the instruction in a very creditable manner.

George Batten and J. V. Coulter offered sufficient steel of any desired analysis to carry out the experimental work.

Thanks are also due Mr. A. S. Gunn, assistant general manager of the Bethlehem Shipbuilding Corporation, Union Plant, for his very kind offer of the use of the Olsen Universal Testing machine to determine ultimates, elastic limits, etc. after treatment, and ''Jimmy'' Coulter intimated that plans are being formulated for the December seance. On inquiry, how-

ever, he failed to divulge whether a blonde or red-headed "mama" had been engaged.

It must be a source of satisfaction to many who have given much of their time, money, energy and attainments to feel that the time is not far distant, if in fact it has not arrived, when Golden Gate Chapter will be a real factor in the development of industrial California, and incidentally play a considerable part in the stabilization of the commonwealth.

The September meeting of the Golden Gate Chapter was called to order by vice-chairman S. C. Alexander at 8:00 p. m., September 14, 1927.

Brief reports were made by chairmen of the various committees. Mr. Gearheart on behalf of the individual members presented a pair of binoculars to Frank B. Drake as a slight mark of their appreciation for Mr. Drake's untiring efforts in behalf of the chapter.

The first paper of the evening "Gears, Their Manufacture and Heat Treatment," by F. A. Brooks, Engineer of the Johnson Gear Co., was indeed well presented and worthy. Mr. Brooks handled his subject from the standpoints of economics, engineering, manufacturing and heat treating. His explanation of formulas used to compute stresses, and the diagrams and charts used to show the distribution of these stresses in tension, compression, torque, etc., was well calculated to increase the degree of respect for the designing gear engineer.

The remarkable high stresses that a properly designed gear could withstand was truly astounding, and many a breast swelled with pride when Mr. Brooks stated that these high qualities could not obtain were it not for a properly controlled heat treatment.

The speaker also pointed out the advantages and disadvantages of oil and case hardened gears depending upon the size and duties required. It was truly a remarkable paper and greatly appreciated if subsequent comment is an indicator.

The second paper, "Welds and Welding," by W. F. Barron of the Linde Air Products Co., was intended to indicate the proper kind of weld—single, double vee and butt, etc.

It was also stressed that certain kinds of welding rods were superior to others. Many pictures, statistics and charts were shown. Along with many advantages of welding, the speaker inferred that there are some conditions where welding was not adaptable. Mr. Barron recommended a careful analysis of conditions prior to welding, and stressed the importance of a well trained personnel. The usual dinner preceded the meeting. *S. R. Thurston.*

HARTFORD CHAPTER

On September 13, the Hartford Chapter, American Society for Steel Treating, met for the first time for the season of 1927-1928 in the Hartford Electric Light Auditorium at 266 Pearl Street, Hartford.

The speaker was J. A. King, New England representative for the Carborundum Company of Niagara Falls, New York, whose talk on "Special Refractories for Heat Treating Furnaces" was well received and created

considerable discussion. Unfortunately handicapped through the failure of his motion picture films to be delivered, Mr. King interested his hearers by sketching the development of specialized silicon-carbide refractories through the past nine years and pointed out the advantages and drawbacks of different types of applications. Also he demonstrated the recent developments in measures that can now be applied to overcome certain characteristics of these materials. Following his talk, an hour was given over to discussions of a general nature regarding heat treating subjects.

A short talk was given on the coming Detroit convention by past chairman A. H. d'Arcambal and secretary H. I. Moore explained the arrangements that he has made regarding transportation and hotel reservations.

This was the first meeting presided over by the new chairman David A. Nemser. The program committee is headed by vice chairman John C. Kielmann and Henry I. Moore is secretary and treasurer.

About 70 members and guests, mostly old stand-bys with a few new comers, were present. Fifteen attended the informal dinner at the City Club.

NEW YORK CHAPTER

The New York Chapter of the American Society for Steel Treating got off to a flying start Monday evening, September 12. At least 100 members listened to Dr. John A. Mathews, honorary member of the National Society and vice-president of the Crucible Steel Company of America, give an interesting account of the importance of chromium in alloy steel metallurgy.

Each person in the audience received a very interesting map of the chromium steels ranging from 0 to 60 per cent chromium and 0 to 3 per cent carbon, on which was marked the regions covered by various patents.

The field is obviously so large that it cannot possibly be exhaustively covered in one evening's discussion, so Dr. Mathews confined his attention to the magnet steels and steels for hot work dies carrying from 2½ to 5 per cent chromium and something less than 1 per cent carbon. He also described the very interesting properties of the steels known as "H.Y.C.C." and "Marathon" containing 10 to 15 per cent of chromium and 2 to 2½ per cent of carbon. He explained some very peculiar properties of these steels as to hardness and magnetic characteristics on his theory that considerable austenite is retained in quenched steels and this austenite decomposes very much more slowly than the martensite formed on the quench.

William J. Priestley of the Electro Metallurgical Sales Corporation said that this theory explained a fact well known among the makers of chromium steel armor plate, namely, that it hardens harder from a 900-degrees Cent. quench than from a 940-degree Cent. quench. *E. E. Thum.*

SPRINGFIELD CHAPTER

The Springfield Chapter held its first meeting of the season on Monday evening, September 26, at 8:00 P. M., at the Technical High School.

Mr. Elwood, of the Youngstown Sheet & Tube Co., Youngstown, Ohio, presented a most instructive and enjoyable moving picture of the manufacture of steel pipe. A number of films were shown describing the charging of blast furnaces with ore, coke, and limestone, tapping the furnaces,

and running the molten metal into a mixer. The operation of a 100-ton open-hearth furnace, also the bessemer converter, was most impressive. Pictures of the pouring of molds, preheating the ingots, rolling the blooms, cropping and forming the billets, all followed in rapid succession.

The making of pipe by both the lap and butt welding process proved of exceptional interest. The details of forming, heating, welding, threading, and testing the finished pipe were plainly given, and Mr. Elwood was most generous in supplying any information desired by the members and guests of the society. *T. C. Kerr.*

ST. LOUIS CHAPTER

The sixty-eighth regular monthly meeting of the St. Louis Chapter of the A. S. S. T. was held Friday evening, September 16, 1927. The attendance of the evening was gratifying, regardless of the extremely hot weather. After the usual dinner the meeting was called to order by our new chairman, W. D. Thompson, who introduced G. Van Dyke, manager of special steels department of the Jos. T. Ryerson & Son, Inc., whose subject was "Commercial Application of Chromium Iron."

Mr. Van Dyke's talk was of a practical nature on all chromium irons, and he touched very lightly on Chromium Steels. His talk carried him through working, welding, forming, heat treating, etc. He had specimens of various operations to illustrate his points.

This was a modern subject and the writer is sorry that more of our members did not avail themselves of the opportunity to hear this interesting talk, which was a very educational one. This was indeed an educational meeting.

There being no further business, Mr. Van Dyke was given a rising vote of thanks. This being the first meeting of the season, the meeting was adjourned until the next meeting, which will be the third Friday in October, when we are hoping to have the picture "The Age of Speed" shown at our Chapter. *C. G. Werscheid.*

TRI-CITY CHAPTER

On the night, September 29, three Tri-City technical organizations held a joint dinner and inspection meeting at the Rock Island Arsenal. More than 185 members and their friends attended. The organizations participating were the Tri-City Chapter American Society for Steel Treating, American Society of Mechanical Engineers, Davenport Engineering Club.

Before the inspection of the large arsenal shop, several talks were given by members of the Tri-City Chapter of the American Society for Steel Treating, who had attended the Annual Show and Convention of the National organization in Detroit last week. Paul Cunnik, of the Rock Island Arsenal, gave a very interesting account of recent developments and practice in the process of making high grade aluminum castings by the Cleveland plant of the Aluminum Company of America. E. Mueller, of the Carpenter Steel Company, reviewed a paper given at one of the technical sessions at Detroit, "The Deep Etch Test for Iron and Steel". G. A. Uhlmeyer, People's Power Co., talked on the fundamentals of Gas

Carburizing. Col. D. M. King welcomed the technical group to the arsenal and told of the advantages of meetings of this nature.

The inspection of the large machine shop at the arsenal along with the products manufactured were of more than ordinary interest. The visiting group were shown completely equipped machine shops mounted on trucks which advance with an army and care for its repairs for mechanical parts. Some of these portable shops contain full sized lathes, drill presses, shapers, milling machines, etc. The group was instructed in the operating details of the recuperator for large guns, which is being built here.

Visitors were more than interested in the operating mechanism of various types of high power guns and howitzers.

A small trench mortar that is replacing the service Stokes mortar was of unusual interest. The unit could be taken down in a few minutes time and made up in packages small enough to be carried away by five men. The great tanks which did such deadly work during the war were the center of attraction.

The tanks are propelled by the famous Liberty motors.

A number of light and fast Whippet tanks were also on exhibition.

Genuine interest was generally shown by members of the technical groups by the manifold mechanical achievements of the arsenal. This can be all the more appreciated when it is realized that all this is being done with the small appropriations allowed the arsenal by Congress. With larger appropriations these developments could be carried on in a much larger way.

The Technical organizations participating in this joint meeting are greatly indebted to Lt. Col. Jenks, Maj. Harmon and Mr. Bombeck of the Rock Island Arsenal for arranging this interesting exhibition and inspection meeting. *G. A. Uhlmeyer.*

ON GRAIN GROWTH IN MILD STEELS

(Continued from Page 621)

member of the metallurgical staff of the Central Steel Co., much new material subsequently collected and not included in that report is given here for the first time. The writer is, therefore, appreciative of the courtesy of the Central Alloy Steel Corp. in granting permission to publish the entire paper and in supplying him with some prints.

He is grateful to Marcus A. Grossmann for reading the initial draft of this paper and for his kindly criticism and suggestions. He also takes great pleasure in acknowledging his debt to his friend and teacher, Edgar C. Bain, who has been most helpful to him at all times.

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